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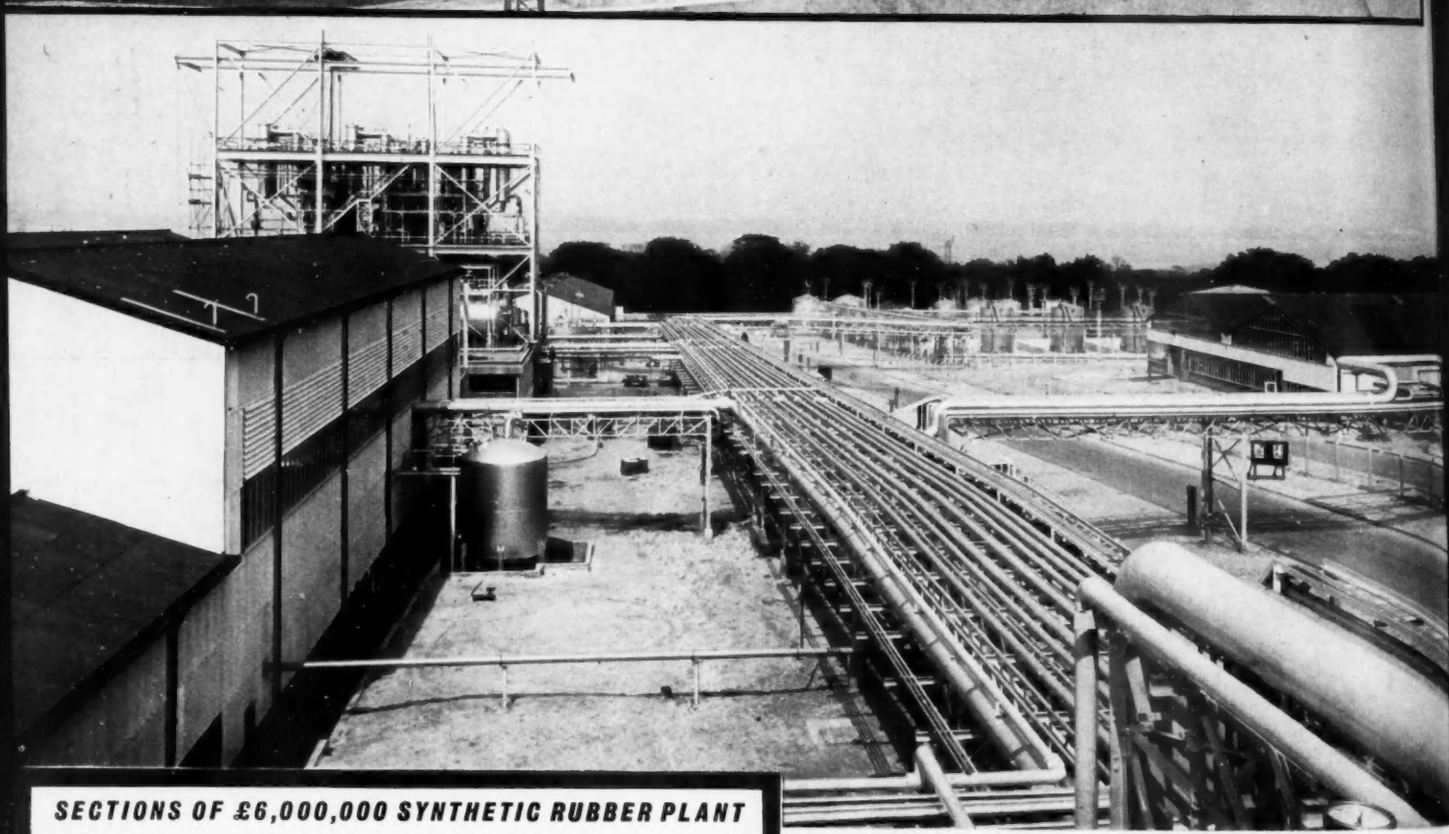

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One of a Crowd

BRITAIN'S ambiguous relationship with other European countries, especially with the six members of the European Common Market, has created suspicion, even anger. It is therefore useful to examine with an objective eye the advantages and shortcomings of belonging to a supranational community, and in particular how the United Kingdom may gain or lose by her decision to maintain a certain remoteness from Euratom.

One of the things that has been made clear by the slowing up of economic activity in the past year is that supranational organisations work best in times of boom. When the big problem is to produce more coal or steel everybody is anxious to get outside help in doing it. When, on the other hand, it is a question of knowing what to do with unwanted stocks, supranational calls to do what is best for the community instead of what is best for the firm are far from welcome.

This is the position at the moment in the European Coal and Steel Community. Belgium has built up big stocks of coal and prohibited imports of German coal. Germany in turn has put a tariff on imports of American coal and reduced the duty-free quota of British coal. For the Americans the tariff of 10 per cent will reduce shipments by 75 per cent. Not all German industry is pleased by these measures to protect coal. Those industries in the north that depend on imported coal are in fact incensed at the increase in their costs. This is particularly true of gas, electricity and steel firms. Many companies have long-term contracts for imported coal made during the days of scarcity. They will either have to break their contracts and pay compensation, or keep them on, and pass on the extra cost to the consumer. Meanwhile, the High Authority of the Coal and Steel Community is considering protests from Britain that the Treaty of Association has been disregarded.

The hullabaloo about the Free Trade Area and the European Common Market has drawn attention away from these other two organisations run by the Six—Euratom and the European Coal and Steel Community—but the fact that neither can be neglected with impunity has been demonstrated in the last few weeks.

First, there is the agreement signed by the British Government with Euratom. This is in nice general terms and covers the exchange of certain information and training facilities, and the provision of technical assistance. The only mention of selling is that the United Kingdom agrees to supply fuel " on request " for use in any British reactors supplied to the Euratom countries. The United Kingdom also agrees to process on commercial terms the uranium fuel burnt in research or power-producing reactors within the Euratom countries.

Compared with the Euratom-USA agreement signed last year, the British agreement is a very colourless affair. The Americans signed up for a joint nuclear development programme involving the building of large-scale reactors with a total installed capacity of 1,000 MW (electrical), to be completed by 1963. Although optimists are pointing out that there is still a long way to go before the Euratom power programme of 1,500 MW by 1967 is filled, others argue that once the Americans have built reactors in the Euratom countries the market is spoilt for us. Against this it is pointed out that the Euratom agreement provides for consultation. And the prototype power-producing high-temperature gas-cooled reactor to be built as a joint international project at Winfrith Heath may help to influence the Continental countries in favour of British designs.

Just how valuable such consultation might be is shown by the example of the Council of Association between Britain and the European Coal and Steel Community. This body was set up in 1954 and has met at intervals since to discuss coal and steel prices and exchange information on subjects of interest. Last year the council had its big moment when it negotiated the reduction of the British steel tariffs, which had incidentally been suspended since the early years of the war. Now with a glut of coal on the Continent, Germany has without warning reduced the quota of British coal allowed in duty free. Protests, references backwards and forwards have followed. The fact remains that the lesson of the United Kingdom association with ECSC is that it works very well in good economic weather. The nature of the Euratom agreement raises very strong doubts as to whether it will be any easier to agree with the Six on nuclear problems.

The case remains arguable. The example of ECSC demonstrates the stresses imposed on a supranational authority by the individual claims of member countries. Yet when we consider Euratom, we find that to remain outside is possibly to sacrifice considerable commercial benefits. Britain's decision is also complicated by the demands of the Commonwealth. To what extent we should belong, is therefore a question to which there is no simple answer.

Cover Picture.—*Two research students in the aerodynamics laboratory of the engineering department at Cambridge University. They are shown engaged in experiments on the effect of distributed suction on the flow in a turbulent boundary layer.*

(*Nurnberg photograph for* ENGINEERING)

* * *

Plain Words

As an Englishman of the traditional kind, I consider it my prerogative, indeed my duty, occasionally to grumble. It serves, I feel, as a mild corrective to the abuses of authority and in any case makes me feel much better. But unfortunately, in these days of mass communication, the grumbles, like everything else, are becoming stereotyped. We grumble by habit rather than design, and in doing so too frequently, may actually encourage the objects of our disapproval. Give dogs—or people—a bad name and they tend to act accordingly. It follows that repetitious grumbling is just bad management.

The vicar of my local parish is an able manager—or at least he has his heart in the right place, which is almost as good. I am a regular and enthusiastic reader of his parish magazine, which is thoughtful, up-to-date and vigorous. The vicar is in fact a bit of a Capricorn himself, and even occasionally gets reported in the daily papers, which is more than can be said for me—last week, for example, he was stated to have expressed the dreadful heresy that watching television did his children far more good than camping with the Scouts. I'm not sure that I agree with him, but I see his point.

At least he has a point. So many of our opinions are the regurgitated views of celebrities, of newspaper columnists, of politicians, of the Establishment, all of which take great care to avoid even the hint of heresy. We pride ourselves on our independence as a nation, but our uniformity becomes increasingly apparent. Soon we shall be divided simply into the orthodox and eccentric. Our vicar may appear a little unconventional, but his fight against the strait jacket of mass thinking is sane and urgent.

But though he strikes at our hypocrisies he is also capable of unexpected praise. In the latest issue he writes: " It is fashionable in some circles to complain of slipshod modern workmanship in general, and the inefficiency of the nationalised industries in particular. I am glad to put on record my entire satisfaction with the way in which the rewiring of the church was carried out by the London Electricity Board. The work was done with the utmost care; no effort was spared to meet our detailed requirements as inexpensively as possible; a number of improvements which we had not thought of were incorporated; no service was ever disturbed, and we were never left without light."

One thing can be certain. Next time the LEB carry out a job for St. Barnabas Church, they will again make every effort to do it well.

CAPRICORN

Weekly Survey

War Potential Within Limits

With the publication of the White Paper on defence called *Progress of the Five-Year Defence Plan* (Cmd. 662, price 9*d*) it is possible to see how far the five-year plan is beginning to work out. The total outlay on defence in the fiscal year 1959-60 is estimated to be £1,514 million, compared with £1,465 million in the current fiscal year, an increase of almost £50 million. The Navy is expected to take about £30 million more and the Air Ministry £16 million more. The War Office estimates are almost unchanged in total, while those for the Ministry of Supply are down by about £1·5 million.

The White Paper begins with a somewhat equivocal statement about the Army. Recruitment, which is now going well, is set a ceiling of 180,000 and this has been adopted to make sure that the Army gets the 165,000 planned for in the 1957 White Paper. It has now apparently become a military dictum that *plus ça change plus c'est la meme chose*. So far as the Navy is concerned, substantial headway is being made with modernising ships and building new ones. Emphasis is placed on planning for limited war and this involves the disposal of a substantial part of the cruiser fleet as well as a number of destroyers. The development of the Blue Streak ballistic missile is to continue and this in quantity will succeed the V-bomber force. One effect of this has been to bring into question the value of the Polaris missile-firing submarine. The argument has also been used that the Blue Streak is suitable for space exploration. Altogether, the Blue Streak does not seem to lack advocates.

Weapons Against Unemployment

Two recently announced Government decisions will go a long way to minimise possible redundancy at Short Brothers and Harland Limited. Early this month the Admiralty announced that the Short Seacat would eventually replace the naval 40 mm gun. The development contract for this missile was announced in April of last year and it is intended to be used by the Royal Navy to deal with aircraft should they evade the outer defensive fighters and long-range guided weapons. It is also intended for use as standard anti-aircraft armament for small ships. It is hoped that a considerable number of Royal Navy ships will have anti-aircraft missiles by the early 1960's. In addition to orders from the Admiralty, Shorts have also been investigating the missile's possible use by Commonwealth, NATO and several other countries.

It was announced last week that the contract for a long-range strategic freighter for RAF Transport Command, which had been expected for some time, had been awarded to Shorts for the SC-5 Britannic. This aircraft, a development of the Britannia, using a large number of the latter aircraft's components, but with a totally redesigned fuselage, can carry the maximum payload of 75,000 lb at an average speed of 360 m.p.h. over a range of 1,400 miles. Alternatively, 30,000 lb can be carried over 5,500 miles. A maximum of 200 troops can be carried.

In announcing this decision, Mr. Duncan Sandys said that although the aircraft was chosen primarily on military grounds, it was obviously of considerable importance that the type chosen should be capable of civilian development. The size of the military order will probably be small; it has not been firmly announced but will almost certainly be less than 20 aircraft and may initially be 10 or less. This is probably another important consideration leading to the choice of the Britannic since the cost of development of a totally new aircraft required in very limited quantities might well be prohibitive.

As a civil transport the Britannic will be in the largest class, capable of carrying a maximum of 197 passengers over a range of 2,600 miles, the civil version being expected to be available in 1963 or 1964.

Longer Reach for German Cranes

The construction boom in Germany has touched off a truly remarkable expansion in a branch of the engineering industry. This is the manufacture of building cranes which has mushroomed up since the war. The main factors in design were the need for cranes that would reach higher, work faster and be able to turn their jibs to a greater variety of tasks. Four types emerged to meet these requirements. They are the rotary tower crane, the telescoping rotary tower crane, the tower climbing crane that grows with the building, and a climbing crane that moves up under its own power as each storey of the building is completed.

The leading firm in this new development is H. Liebherr of Biberach-Riss, whose London agents are Tower Cranes Limited. This firm makes 16 types of tower crane with capacities from 4 to 100 metric tons, as well as several kinds of climbing crane. Another prominent make is the Peine, whose makers claim to have produced the world's tallest rail-mounted crane and the first crane with wireless remote control. The major proportion of export sales among German crane makers has been achieved by Krangemeinschaft Hillgers-Voegele. This firm's biggest crane, the Buildmaster 52, has a maximum height of 195 ft, a radius of 98 ft 6 in, and a load of 4 tons. It has been particularly successful in this country with tower cranes. It is represented by Abelson and Company (Engineers) Limited, of Sheldon, Birmingham.

Agricultural Engineering College

A new college of agricultural engineering is soon to be established by the Ministry of Education in co-operation with the agricultural industry. It will be called the National College of Agricultural Engineering and is expected to cost £250,000. It will have accommodation for between 60 and 100 students and its purpose will be to provide advanced courses, including sandwich courses, for a diploma. Sir Eric Ashby will be chairman of the governing board.

The college is to be sited near the National Institute of Agricultural Engineering at Silsoe in Bedfordshire. The cost of the land and the building will fall primarily on public funds, but the agricultural engineering industry has undertaken to supply a substantial amount of the equipment. The industry has also indicated its willingness to support a number of sandwich-course students each year.

This new college fits in with the approved pattern for national colleges. These are set up for industries which have only a small demand for specialised advanced education and cannot be economically provided for in courses established by local education authorities. The Exchequer takes on the cost of establishing and running such colleges with the help of the industry concerned.

Scheduling Smoke Control

The reappearance of " smog" has proved quite conclusively to residents in large towns that whatever has been done so far in establishing smoke control has made no appreciable impact on the problem. An important circular has now been sent by the Minister of Housing and

Local Government, Mr. Henry Brooke, to Local Authorities in England and Wales asking them to complete and return a questionnaire "showing their phased plans for establishing smoke control areas year by year to 1963, stating the final objective, and the target year for the completed programme."

The Minister points out that "about half the smoke in the atmosphere comes from domestic stoves and fireplaces burning coal," and that most of it is discharged at a low level. He urges faster progress, especially in removing the smoke pall from the "black areas" where air pollution is the worst, and suggests that new housing estates should be "smoke controlled from the outset." Further, he hopes that the small number of urban authorities in black areas who have not yet made a building byelaw for smokeless heating and cooking appliances in new buildings will now do so. The National Society for Clean Air have passed a resolution deploring "the appearance of advertisements on behalf of the domestic raw coal fire" and point out how contrary this is to the wishes of Parliament embodied in the Clean Air Act.

The Society have published the proceedings of the Llandudno Conference, 1958, in booklet form (price 12*s* 6d, National Society for Clean Air, Palace Chambers, Bridge Street, London, SW1), in which are included reports from the Society's regional councils and scientific papers on the dangers of air pollution and the means of avoiding it. Quicker progress could doubtless be made, but the means are not always available. Considerably increased supplies of smokeless fuel are required, and an increase also in the number of suitable boilers, space heaters and other appliances. The headway made in the past year or so by the advocates of small-bore central heating (mainly by oil or anthracite) is evidence of the public's wish to have better and more efficient heating. Cash may, however, set a limit to the speed at which the changeover can be effected.

Tractor Power Spread

There are at present more than 500,000 tractors in use on British farms compared with a figure of only 50,000 in 1938. In assessing the degree of mechanisation of British agriculture these figures do not give a complete picture, since the popular tractor size at a time as recent as 1948 was about 25 h.p., while the sizes most in demand at present start at about 30 h.p. and go up to as high as 50 h.p. or more. The question of whether British agriculture was over-mechanised to an uneconomic degree was discussed last week at the National Power Farming Conference at Harrogate. Such a question is extremely difficult to answer in general terms. Mr. David C. Haney, director of sales for the International Harvester Company of Great Britain Limited, suggested among other points that there was a real need not only for more power but also for less power. In other words, the wide variety of work on the average farm can best be carried out by using tractors of a wide range of horse-powers. Standardisation on one type in the middle of the horse-power range could well lead to uneconomic employment on light jobs and costly waste of time when heavy jobs need to be done rapidly.

Mr. F. G. Sturrock, of the School of Agriculture at Cambridge University, put forward a method of testing whether machinery was being used economically on any particular farm. He pointed out that hitherto the figure of "machinery costs per acre" had been used but that this was obviously faulty since costs vary according to the crops and livestock kept on these acres. A recently devised test which he described is based on the calculation of "standard tractor hours," depending on the acreage under various crops. From a standard table it is possible to calculate the standard tractor hours for a farm, to divide the total cost of machinery for a year by this figure and obtain the cost per 100 standard hours. On this basis a much sounder comparison can be made between the mechanisation costs of different farms.

This test also provides a good system for estimating the number of tractors needed to run an arable farm, though obviously the detailed economics of each particular case must be taken into consideration. Whatever fears there may be that the market for tractors in this country is saturated, the speakers seemed agreed that there was still room for further mechanisation.

Far Flung Research

One of the outstanding beneficiaries of the development of air communications in the last few decades has been research work in the United Kingdom overseas dependencies. Much of the work has always been of a high quality and a great deal of progress has been made, especially in medicine and agriculture. As a booklet put out by the Central Office of Information (*Research and the United Kingdom Dependencies*) points out, there were a number of outstanding early discoveries and developments dating back to 60 years ago when Sir Ronald Ross discovered the cause of malaria and the two schools of tropical medicine were established, one at London and the other at Liverpool.

Such work has always been dogged until recently by the isolation of those on the spot. Men of the highest qualifications were unwilling to do a tour abroad in the tropics although they could be recruited on to advisory committees in London. This was for long the main criticism of the expert advisory system developed by the Colonial Office. Eminent men would lay down the law as to what should be done and how scarce funds should be spent, with at times less than due regard to the difficulties of the men on the spot, who might be technically somewhat out of date, few in number and over worked, with limited funds and little equipment.

The Colonial Development and Welfare Acts (the first was passed in 1940) provided for the first time assured if limited resources for research in the Colonies. The critical factor was probably, however, that air communications at that time were just beginning to bring the tropics within a few hours' flying time of London and New York. Isolation began to break down and experts in Europe and America became more willing to go and see. The result has been a remarkable growth in research contacts, both within the Commonwealth and internationally. The American exports of dollars and technicians has come in contact with the Commonwealth effort, to the mutual advantage of both. Research fellowships and pools of scientists have been established to keep workers overseas reinforced with the latest knowledge and techniques. Much remains to be done and the size of the task will increase over the next few decades as industries become established in under-developed areas and the demand for technological assistance grows. In the last two decades, however, a much improved "climate for discussion" has been created to help research work forward in the dependencies, and no small share of the credit goes to the Colonial Office itself.

The Duke of Edinburgh has enlarged on the need for scientific co-operation in the countries of the Commonwealth. During his speech to the Pakistan Association for the Advancement of Science on 7 February, the Duke said that such co-operation could be divided under the headings: regular discussions of general scientific problems and of those peculiar to the Commonwealth; consideration of administration problems; regular exchange of information; the movement of scientists; and technical help and advice.

He said he would like to see the system of the British Commonwealth scientific offices extended to other Commonwealth countries. Many Commonwealth countries were doing original research of great interest.

Letters to the Editor

TRAFFIC IN LONDON

Victoria Line

SIR, In the leading article entitled "Grasp this Nettle" in your publication of 13 February, reference is made to the paper by Mr. F. S. P. Turner on the subject of the proposed Victoria Line which was read at the Institution of Civil Engineers on 3 February. Allusion is also made to some remarks with which I opened the discussion on that paper, and I feel that I must protest since your article ascribes to me views which I certainly do not hold on the subject of underground railways in general and the Victoria Line in particular. The record of the discussion, which will in due course appear in the *Proceedings* of the Institution, will fully support this statement.

In the opinion of many who were present, the paragraph of which I complain runs completely counter to the general tenor of my remarks; in fact I pointed out that there was a mass of evidence to show that underground railways were an essential requirement in a large city, and that it was not unreasonable to suggest that their provision should not depend solely upon whether or not they could be run at a profit. An adequate system of sewers, a fire service and a road system were also necessary, but were not expected to make a profit.

In my view the appalling traffic conditions in London at the present time are occasioned by the enormous inflow of private cars every day and congestion of the streets by parking. The great majority of the users of these cars live on the underground railway system. An extension of this system might encourage them to use it.

Yours faithfully,
H. D. MORGAN.

Sir William Halcrow and Partners,
47 Park Lane,
Westminster, W1.

17 February, 1959.

CLEAR THINKING NEEDED

Suggestions Schemes

SIR, I have read through *Successful Suggestion Schemes* and the subsequent interesting correspondence in your columns. It does appear to me that *if any* vital comparison can be made of the results, as published in the booklets, for 1956 and 1958, it must be confined to the 190 firms common to both surveys; numerical and other changes during the two-year period will upset the validity to some extent, but, spread over 190 concerns, this should not be too important.

I cannot help wondering why these data were not given for the 190 companies and hope that the figures may now be supplied.

Yours faithfully,
C. H. LATIMER-NEEDHAM.

High Oaks,
Wonersh,
Surrey.

14 February, 1959.

SIR, Of the many and varied points of view, together with formidable statistics, given by correspondents under this heading, none appears to have really considered the importance of the *actual source* of such suggestions, together with factors influencing the response.

The promotion of such schemes throughout industry entails (*a*) persuading reluctant employers to adopt a scheme of this kind, and (*b*) assisting interested employers to adopt a scheme. From this point it becomes a matter of employer/employee relations as to its success (or otherwise). The requirements are: first, that the employee shall feel that the management really are interested in his (or her) suggestions

Continuing

Letters to the Editor

and that they are not regarded as irksome by-products of the works committee; and secondly, that the awards for suggestions adopted should bear some reasonable relationship to the company's direct savings in materials/production time or the hidden savings such as ease of access/maintenance, etc.

Unfortunately, it is not always true that the awards bear this relationship; there being cases where the policy is the payment of an absurdly small percentage of the apparent monetary gain to the company. I say "apparent" again, because, if a substantial payment can be justified, then an effort should be made to do so, otherwise the result is apathy on the part of the employees.

One is, after all, asking shop personnel to devote thought and also, possibly, time and energy, to problems outside the scope of their normal work. Results, therefore, human nature being what it is, will not be forthcoming in sufficient quantity and quality unless such personnel can see a reasonable gain, financial or otherwise.

There would appear to be a great deal of work yet to be done in convincing many managements that such schemes can be of worthwhile benefit to them and also in overcoming the natural prejudice of some design and supervisory staff.

Yours faithfully,
J. D. LOCKWOOD.

73 Harewood Road,
Chelmsford,
Essex.

11 February, 1959.

NUCLEAR SCIENCE IN THE USA

Studies at Argonne

SIR, Thank you for giving recognition to the Greek scientists and engineers who have participated in training at the International School of Nuclear Science and Engineering, Argonne National Laboratory (operated by the University of Chicago), as noted in Atomic Review of 9 January 1959. To date, 325 scientists and engineers from 43 countries of the free world have completed training at the School. Another class of 57 scientists and engineers began their training here on 4 February.

You may be interested to know that applications are invited from up to 15 scientists and engineers for direct entry into the International School in the following session, which begins at Argonne National Laboratory in August, 1959. Qualifications for entry into the course of 17 weeks includes at least a bachelor's degree in a regular physical science or engineering discipline, an elementary knowledge of reactor physics, and knowledge and practice in the physics of radiation detection and measurement. In addition, sponsoring of the applicant by an employer is required. The tuition fee is $1,000 for a 17-week period. Application forms and more complete information on the training programme may be obtained by writing to the International School of Nuclear Science and Engineering, Argonne National Laboratory, Box 299, Lemont, Illinois, USA.

The information contained in the Atomic Review is of interest to our faculty and participants. We shall continue to bring it to their attention.

Sincerely yours,
R. G. TAECKER,
Director.

International School of Nuclear Science
and Engineering,
Argonne National Laboratory,
Box 299, Lemont, Ill., USA.

10 February, 1959

Obituary

SIR OWEN RICHARDSON *Thermionics Research*

The death of Sir Owen Richardson, F.R.S., at his home in Hampshire on 15 February, at the age of 79, has removed a scientist distinguished for his original researches in thermionics. For no less than 20 years he was director of research at King's College, University of London, and, in 1928, he was awarded the Nobel Prize for Physics.

Born of middle-class industrial parents at Dewsbury, Yorkshire, on 26 April, 1879, Owen Willans Richardson developed a taste for science at a very early age and owed much to the encouragement which his father gave to these youthful inclinations. The boy's endeavours secured him a scholarship from the local St. John's Church Day School to Batley Grammar School. Here, he followed his bent, and his industry in chemistry and physics was rewarded in due course with a scholarship to Trinity College, Cambridge. A fellowship followed in 1902, when he was 23. It was his good fortune to receive his honours early. In 1906, at the junior age of 27, and while still a fellow at Cambridge, he was elected Professor of Physics at Princeton University. His Nobel Prize came when he was a comparatively young man of 49 and at the summit of his work. He was made a knight bachelor as long ago as 1939.

Richardson remained in the United States for around eight years, during which time his original researches into the basic principles of atomic physics gained him widespread regard both in that country and in Britain. He left the States in 1914 to become Wheatstone Professor at King's College, London, and, thereafter, his academic career was largely bound up with that college. His occupancy of the Wheatstone chair lasted for ten years, until his appointment as Yarrow Research Professor of the Royal Society (which also conferred its fellowship upon him) and director of research at King's. These appointments carried no teaching or lecturing responsibilities and he was thus able to devote his very considerable energies to research questions. It was in 1932, during this period, that he returned to the United States to deliver the Silliman memorial lecture at Yale University.

When, in 1944, at the age of 65, he retired from his appointments, he was made a professor emeritus in the University of London. Among his services to science may be mentioned his presidency of the Physical Society during the session 1926-28, his holding of office as the Society's honorary foreign secretary for many years, and his corresponding membership of a number of foreign academies. To all of these offices, and to others, it was his unvarying custom to give of his best.

He will be remembered most for his original investigations into the laws governing the emission of electrons *in vacuo*. His efforts in this field put thermionic physics on to a firm scientific footing and must rank with the work of such scientists as Sir Ambrose Fleming and Irving Langmuir in its importance to the early development of electronic engineering.

Unlike many of his contemporaries in the early days of thermionics, Richardson was not only a practical experimenter but was also a sound theoretician. His theoretical studies, combined with diligent practical research, led him to discover the law, universally known as Richardson's Law, which relates the current density of an emitter to its absolute temperature and thus forms the basis of a theoretical understanding of thermionic physics.

MR. HARRY AUSTIN *Motor Car Pioneer*

By the death of Mr. Harry Austin, which took place at his home at Northfield, Birmingham, on 8 February, the world has lost yet another of the pioneers who devoted themselves to the development of the motor-car.

He was born at Wentworth, Yorkshire, in April, 1876, and was thus some ten years the junior of his brother Herbert, afterwards Lord Austin of Longbridge, who died in 1941. Both brothers spent their entire careers in the motor industry, beginning in the works of the Wolseley Sheep Shearing Company Limited. Herbert had returned from Melbourne in 1890 to control the manufacture of the Wolseley sheep shearing machine and it was in the firm's workshops that the two brothers produced together the first Wolseley motor-cars.

When Herbert commenced the manufacture of motor-cars on his own account at Longbridge Works, Northfield, Birmingham, in 1905, Harry became superintendent of the chassis shop, a post which he retained until his death. The two brothers worked together on the building of the first Austin car at the new factory and, in 1946, it fell to Harry's lot to experience the satisfaction of supervising the production of the millionth car to be constructed at Longbridge Works. It was in the same year that he celebrated his own golden jubilee in the motor industry. Harry Austin was indeed a motor-car pioneer; few men having lived a life so closely allied to its development, experiencing as he did every phase of advancements in production methods. Latterly, he had become somewhat deaf in his left ear, and attributed this failing to the early times of the industry, when he used to lie on a motor-car mudguard listening to the sound of the engine when his brother was testing the firm's cars.

Unassuming to the point of being shy, perfection in the development of the motor-car was his whole aim in life.

★ ★ ★

RUBBER TECHNOLOGY OVERSEAS

Companies and personnel in South Africa engaged in rubber and plastics manufacture are being invited to apply for membership of a new section of the Institution of the Rubber Industry which is being set up in that country. The Institution is forming a central council in Johannesburg, and branches in Johannesburg, Durban and Port Elizabeth, with the duties of developing polymer science and technology, of encouraging technical education, and of providing a means of association between persons engaged in the rubber industry throughout the territory of South Africa.

Honorary secretaries have been appointed as follow: Mr. F. C. Moore, PO Box 4142, Johannesburg; Mr. A. J. Robertson, PO Box 1515, Durban, Natal; and Mr. W. Pickup, PO Box 3062, North End, Port Elizabeth. The headquarters of the Institution are at 4 Kensington Palace Gardens, London, W8.

Plant and Equipment

FLASH DISTILLATION PLANT

Standard Sizes for Sea Water

FLASH distillation offers several advantages over other forms, particularly for marine use. As there is no body of water to slop about when the ship moves, the risk of priming from splashing is removed, nor does it occur as a result of alterations in vacuum or heat input. Moreover, there are no submerged heating coils and scale formation is virtually eliminated as there is no heat transfer surface; as a result the plant can operate for long periods without attention.

The particular plant which has been developed by Buckley and Taylor Limited, Castle Iron Works, Oldham, is shown in its prototype form in the accompanying illustration; the diagram indicates the flow through it. Special claims are that the plant is very efficient and requires only a low grade source of heat. Even in the smaller sizes of marine plants where maximum efficiency has been sacrificed to keep down size and weight, at least 2½ lb of distillate can be obtained from 1 lb of steam; for large land plants (and sizes up to 200 tons per hour are in the design stage) this figure could rise to 8 lb per 1 lb of steam. At present four sizes are immediately available producing 25, 50, 75 and 100 tons per 24 hour day. The smallest has three stages and requires about 580 Btu per pound of distillate, while the others have four and need only about 370 Btu per pound.

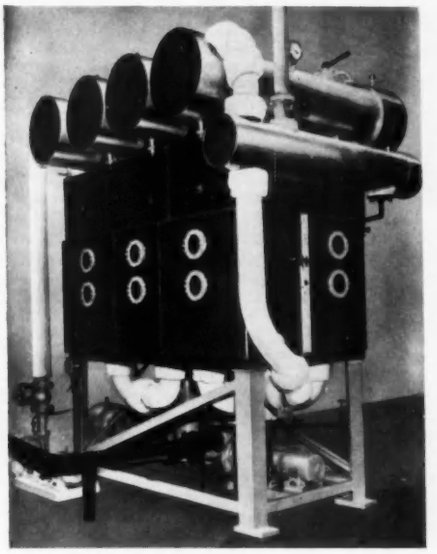
The sets, known as Aquaflash, work on the counter-current principle. The raw sea water (that is, the feed) also serves as the coolant for the condensers, being successively heated thereby. Typical temperatures are indicated on the flow diagram. Heat is supplied at the one point only; it can be from any source, low pressure steam, diesel engine exhaust gases or cooling water, gas-turbine cooling water or exhaust gases, or the like.

Keeping the feed temperature to about 180°F prevents the formation of hard scale in the heat exchanger (the only spot where it is likely to form); only a soft sludge is formed which can be swept out of the tubes (the feed passes through the tubes) in a matter of half an hour or less. As may be judged from the diagram the production plants differ from the prototype in that the condensers are mounted inside the main casing, thereby making a neater construction which is easier to lag and which also has fewer pipe joints. Apart from the primary heater which varies to suit the source of heat to be used, the remainder of the plant is built up of standard units.

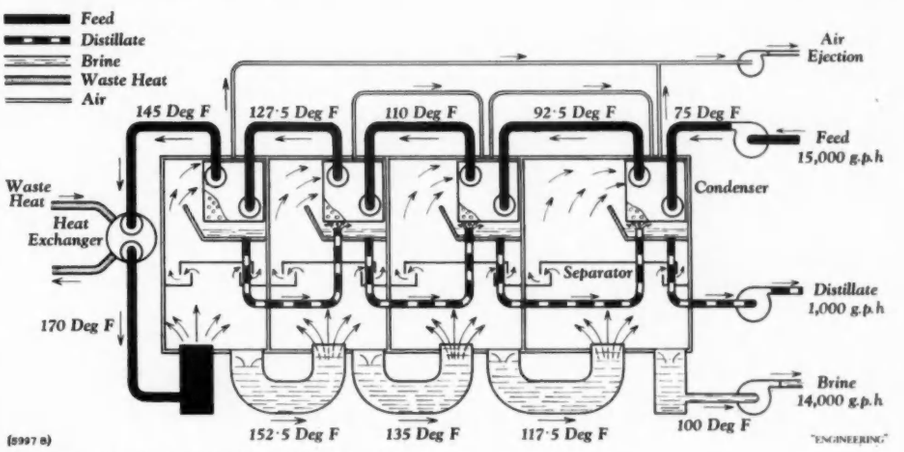
The first stage of evaporation is also one of de-aeration and for this reason the extraction line is kept separate. (Carbon dioxide also comes off at this stage, reducing corrosion risks.) The incoming feed is directed in such a way that there is no tendency for drops to be carried over into the condensate; in addition there is a baffle to complete separation. This baffle is of a simplified form compared to those currently in use, enabling the height and cost of the plant to be reduced. Excess feed passes through the U-tube to the next stage where evaporation again takes place at a lower pressure. The process is repeated in the remaining stages.

The vapour condenses on the tubes and collects in the trays below. It again flashes off on reaching the next stage, the heat extracted being used to heat the feed water. The final product is of high purity and is suitable for drinking or for boiler feed. It is pumped away to storage tanks or wherever it may be required. The excess brine is also pumped away and disposed of. A relatively large feed is used—some 15 gallons per gallon of condensate—which means that the brine rejected is still not very concentrated and therefore less liable to cause corrosion within the plant. The amount of heat rejected with the brine does not warrant the complications of recirculation.

The method of air ejection can also be varied to suit the particular application. Normally in marine installations, and in some land plants, there is a supply of steam available and therefore a standard steam ejector can be used. Where steam is not available, however, the ejector can be replaced by a motor driven pump. For the 50 ton per day size the total power requirements for pumping do not exceed 20 h.p.



The Aquaflash distilling plant is available in standard sizes



The principle of counter currents is used for the flow; heat is only added at the one point.

FLOATING STRAINER

The Dolphin strainer has been produced to meet the need for a pump intake that will float on the surface of the water and so avoid drawing in silt or mud from the bottom. It is being made in four sizes by Megator Pumps and Compressors Limited, 43 Berkeley Square, London, W1, to fit hoses of 1½, 2, 3, and 4 in diameter.

The material is a tough plastics which can be dropped from considerable heights, or otherwise very roughly handled, without breaking. The float element is an expanded plastics which does not absorb water, and therefore the case can be pierced without causing the strainer to sink. Below the float section is the suction "box" which is surrounded with a plastics grating to prevent the ingress of larger pieces of matter, the useful area being such that half the holes can be blocked before the pump flow is restricted. Float and suction box are free to pivot on the hose connection (which is also plastics) so that the strainer will always float the right way up no matter how much the hose may be twisted. Moreover, the intake ports on the connection are arranged at the hose end so that more than half the strainer can be out of the water before air is drawn in. Being very light, it can rest on the bottom without sinking, even when the latter is very soft mud.

The Dolphin strainer floats on the top of the water, always with the intake underneath.

Continuing **Plant and Equipment**

SIMULATING DELAYS *for* ANALOGUE COMPUTERS

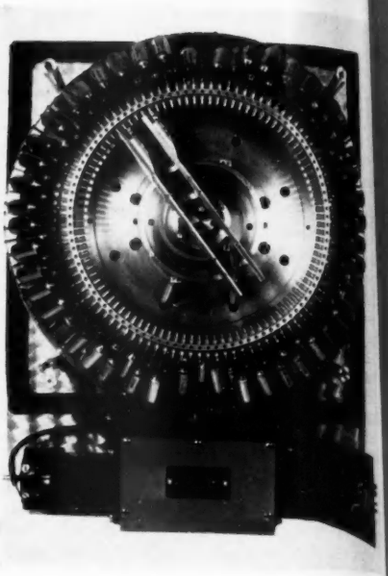
An instrument that simulates the large transit time effects occuring in some industrial processes is being made by Elliott Brothers (London) Limited, Boreham Wood, Hertfordshire. Such effects are usually associated with the flow of fluids in ducts, and the instrument is designed for use in conjunction with analogue computing equipment working on problems of this nature. Delays of between 2 and 60 seconds can be produced, and the delay can be varied in proportion to another fluctuating plant parameter, if required.

Basically the instrument, called the type ND. 111, consists of 100 condensers that are charged in turn by a rotating contact—the "writing" wiper—and discharged approximately one revolution later by a second rotating contact —the "reading" wiper. The pattern of voltage that is to be delayed is fed to the writing wiper and the delay before the same voltages appear at the reading wiper is proportional to the rate of rotation. The mechanical arrangement of the device is shown in the illustration.

The two wipers are situated close together on the rotating arm, the leading wiper doing the reading. One hundred 22,000 pF condensers are connected to the fixed contacts, which are mounted in ceramic bushes in a Dural ring. The existence of an air gap between each of the fixed contacts avoids leakage effects that might be caused by transfer of contact material over the surface of a solid insulator.

Since from the methods of construction the process is essentially discontinuous, the output signal appears in a number of discrete voltage steps. This feature determines the maximum signal frequency transported, when considered together with the range of transport time and accuracy required. There being 100 fixed contacts, with a spacing between reading and writing wipers equivalent to 1·5 of these, the output signal comprises some 98 samples per transit time. A small smoothing capacitor in the reading amplifier prevents the output from falling to zero during the transport of the wiper from one contact to the next.

Both the reading and the writing amplifiers are of unity external gain, able to handle a range of voltage from − 100 to + 100 V. A servo drive system is so arranged that for input voltages applied to it from 3·3 V to 100 V, the motor rotates from 100 to 3,000 r.p.m., a 100: 1 step-down gear train providing the required speed at the switch shaft. The system is capable of rotating at significantly lower speeds, giving larger transit delays, but the linearity between shaft speed and input signal is no longer maintained.



A delay in electrical signals is introduced by the time taken for the leading contact to collect the voltages written into the condensers by the trailing contact.

AIR COMPRESSOR *for* DENTAL DRILLS

To meet the need of the dental profession for a small, high performance, silent and trouble-free compressor to operate new air turbine driven drills, Alfred Bullows and Sons Limited, Long Street, Walsall, Staffordshire, have produced three new Hydrovane compressors.

The first of these, the 2AR301E, has been designed especially for use in the dental surgery. It is silent in operation, and reliable in performance, and has a complete absence of vibration. Contained within a fibre-glass cowl the rotary air compressor is mounted on the receiver and is driven by a ½ h.p., 960 r.p.m. electric motor wound for 200/240V,50 c/s supply, for which 6 ft of cable is provided. The operation is controlled by a pressure switch having a range of 35/40 lb per sq. in. An activated charcoal filter ensures surgically clean air. The second unit, the 3AR301E, is identical to the 2AR301E except that it incorporates a 1,440 r.p.m. motor. It is shown in the illustration on the left with the cowl removed.

The third unit, the 2R300E differs from the others in that the air receiver, the pressure switch, the oil return valve and the glass fibre cowl are omitted. Performance is, however, identical with the 2AR301E and operation is by means of the existing foot switch.

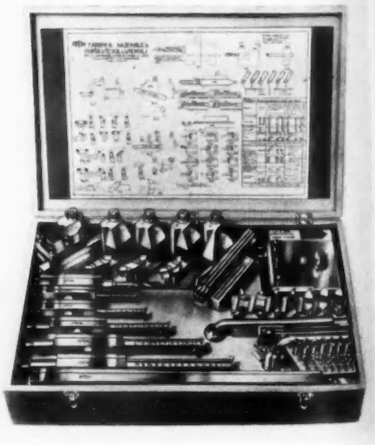
LIGHTWEIGHT SUPPORT LEG

A new lightweight support leg for use in conjunction with their range of rock drills has been introduced by the Consolidated Pneumatic Tool Company Limited, 232 Dawes Road, London, SW6. This unit, which is alternative to the standard range of steel airlegs, has a a weight of 32 lb and is fabricated from the light alloy Dural. Specifications include a stroke of 4 ft, a bore of 2¼ in, and an overall length, when closed, of 5 ft 10 in. The length when fully extended is 10 ft 1 in. The new unit represents a weight saving of 26½ lb as compared with the equivalent steel version.

UNIVERSAL LATHE TOOLING

The Italian-made "Impero Unificatore" lathe tooling set, which is now available in the British Isles and Commonwealth from A. A. Jones and Shipman Limited, Narborough Road South, Leicester, covers a wide range of internal and external turning operations with a comparatively small number of standard tools. Three double-headed tools, in fact, mounted in a special body in place of the normal lathe toolpost, replace 12 ordinary-sized turning tools. In addition, the tool holder body can take boring, parting, knurling and other tools, including standard twist drills.

All the tools, which are of high-grade cobalt steel, tipped with one of three types of alloy according to the material being cut, can be set accurately and interchanged quickly.



A small set of "Unificatore" tools and a tool holder can carry out most turning operations on a lathe.

Companies in the News

Controversial Filament

Heavy guns were fired, in support of Britain's claim to have seen the birth of the electric lamp, by Dr. J. N. Aldington at the Golden Jubilee celebrations of the Illuminating Engineering Society held at Newcastle upon Tyne recently. His talk was to an audience of some 500 people, among whom were the Lord Mayor of Newcastle and the mayors of Gateshead and Sunderland. The chairman was Sir Joseph Swan's son, Sir Kenneth. Dr. Aldington is managing director of Siemens Edison Swan, the company that combined the interests of Siemens Edison Swan Company, which sprang from Swan's original lamp company, and of Siemens Brothers, whose dynamos were used to provide electric power for many of Swan's early installations.

Entitled " Sir Joseph Swan and the Development of the Electric Lamp," the lecture began with a survey of the activities of Swan in fields other than electric lighting. He had been apprenticed to a Newcastle chemist and applied his inventive genius to the field of photography in the first instance, developing a new method of photographic collodion (which remained the standard method of such production for 90 years), a carbon process of photographic printing, a copper printing block process and others. Dr. Aldington demonstrated Swan's method of producing squirted cellulose fibres for lamp filaments, which led to the establishment of the artificial silk industry.

Swan's lamp work was fully described, most of it carried out alone in his spare time while Edison was working in a laboratory in America with some 80 assistants. " My investigations into the unique contributions made by Edison and Swan," said Dr. Aldington, " cause me to state most categorically that it was Swan who made the fundamental step in the invention which resulted in the carbon filament lamp, precursor of the electric lamp today." A comment on the lamp industry's development: more than 10,000 types and sizes of lamp are in production throughout the world at the present time.

Gyroscope Reoriented

Sperry Gyroscope Company have substantially reorganised their administration, " to take into account the changing pattern of their activities." The main objective is a decentralisation of management and the establishment of three separate operating divisions, each embracing its own sales, design and manufacturing effort. These three divisions will be known as the Brentford, Bracknell and industrial divisions. Although no centralised activities appear to be envisaged other than those embracing the legal, financial and industrial relations functions, provisions have been made for " the fullest interchange of technical information and facilities " so that " the full resources of Sperry can be brought to bear on any project that may require them."

The company's rapidly growing interests in industrial control engineering will be concentrated in the new industrial division. These interests include hydraulics for both industrial and aircraft applications, electromechanical components, such as synchros, inductive pick-offs and similar servo units, process-control components and systems, automatic machine control, measuring systems and components, non-destructive testing equipment, control systems and instrumentation for nuclear-energy projects and for process control work. The Brentford division will be responsible for the company's aeronautical, marine and naval activities and the Bracknell division will concentrate on Government contract work for guided weapons and inertial navigation.

Mr. Robert Broadbent, who has been a director and general manager of the company for several years, has been elected as a managing director. The three divisional managers, Mr. M. L. Jofeh, industrial division, Wing Commander J. C. G. Bell, Brentford division, and Mr. H. B. Sedgfield, Bracknell division, will report to Mr. Broadbent.

Berth for Supertankers

Major harbour contracts have recently been won by Richard Costain in the Middle East in connection with the handling of large oil tankers. Last month they were awarded a £4 million contract for constructing a jetty and boat harbour in the Persian Gulf. They have now announced the award of an even bigger contract, valued at £4½ million, for the construction of a deep-water berth for supertankers in the Gulf, as a joint venture with Raymond International and the DeLong Corporation. The project is being undertaken for the Basrah Petroleum Company Limited, and the consulting engineers are Rendel, Palmer and Tritton.

The berth will be constructed about 20 miles out to sea off the mouth of the Shatt-al-Arab river, and will consist of a centre island 400 ft by 240 ft, with mooring dolphins at each end connected by steel bridges, and thence by other bridges to a tug berth and helicopter deck at one end and an accommodation platform at the other. Overall length of the structures will be about a quarter of a mile. The island will be a structural steel frame on steel tube piles, with a timber deck; piles and steelwork being supplied by South Durham Steel and Iron Company. A shore base will be established at the port of Fao in Iraq, for the assembly of materials which will be used in the construction. Work is to start immediately on the fabrication of the steel and the construction of specially designed barges, which will be towed out to the Gulf. It is hoped to complete the contract by January, 1961.

Bristol Siddeley Engines

Details have now been released of the pattern of the new organisation which has resulted from the decision by the Hawker Siddeley Group and the Bristol Aeroplane Company to merge the activities of Armstrong Siddeley Motors Limited and Bristol Aero-Engines Limited. The new company, Bristol Siddeley Engines, is acquiring the complete share capital of ASM and BAEL, and will take over the whole of the operations of both companies. The share capital of BSE will be held equally by Hawker Siddeley and BAC. Bristol Siddeley Engines will also acquire Bristol Cars Limited.

The board of BSE has been constituted as follows: Sir Reginald Verdon Smith, chairman; Sir Roy Dobson, vice-chairman; Mr. H. T. Chapman, deputy chairman (resident in Coventry); Sir W. Alec Coryton, deputy chairman (resident in Bristol); Sir Arnold Hall, managing director; Air Commodore F. R. Banks, sales director; Mr. B. Davidson, commercial director; Mr. G. L. Hack, assistant production director; Dr. S. G. Hooker, technical director (aero); Mr. W. H. Lindsey, technical director (non-aero); Mr. W. Masterton; and Mr. W. F. Saxton.

Keen Eyed Centenarian

Thomas Potter Limited, of Glasgow, celebrated this month 100 years of successful trading. They are one of the biggest stockists of engineering equipment in Scotland. They are described as " engineers, shipbuilders and public works contractors' furnishers," and stock some 7,700 different products for these industries, ranging from nuts and bolts to tower trucks weighing over 1,000 tons. They are managed by the third and fourth generations who appear to have lost none of the drive and initiative of those who built the business.

An interesting aspect of their activities is an extensive export trade, mainly to Commonwealth countries. Their ability to change with the times is doubtless the source of their continued success. Having provided fittings for the Queen Mary and the Queen Elizabeth they have also supplied material for atomic power stations at Dounreay, Calder Hall and Hunterston. In their own words: " stocks are constantly changing with developments in industry and we focus an experienced eye on the modern trends." At 41 Arcadia Street, they have a permanent display in a new showroom.

Joint Concern for India

A large scale engineering undertaking has been set up by Associated Cement Companies of India (ACC) in association with Vickers Limited and Babcock and Wilcox Limited. ACC, who hold 49½ per cent, of the issued capital, provide the chairman, Mr. Dharamsey M. Khataum, who is also chairman of ACC and a director of a number of important Indian undertakings. Vickers and Babcock each hold 24¾ per cent of the shares and provide two directors each (Mr. A. H. Hird and Mr. T. A. H. Harrison for Vickers; Sir Kenneth Hague and Mr. J. Stewart Robertson for Babcock). Mr. John Marks is managing director and Mr. G. R. Tongaonkar his deputy.

The project has been under consideration over a considerable period and has received both encouragement and support from the Indian Government. A large works is to be built by the new company at Durgapur in West Bengal for the manufacture of heavy engineering products, such as cement making machinery, boilers, pressure vessels, winders for the mining industries and other engineering products. Technical assistance will be provided by the three main shareholders. Construction on site will begin shortly and it is expected that actual production will begin in 1962.

The formation of this large new company, ACC-Vickers-Babcock Limited, is described as " a great achievement in the development of the heavy engineering industry in India." It is a timely recognition of the inevitable national character of such development and sets a useful pattern for further joint enterprises of this type.

Ferranti Transformers

Considerable progress has been made during 1958 by Ferranti Limited in the production and sale of large power transformers. Output during the year totalled over 3 million kVA, including three 120 MVA, 275 kV and two 145 MVA, 70 kV supplied to the Central Electricity Generating Board. The first 330 kV, three-phase transformers to be manufactured in Great Britain were completed during the year. These comprised a 120 MVA auto transformer and series booster, and two 60 MVA double wound transformers for the Kariba hydro-electric scheme in Southern Rhodesia.

The company's progress overseas has continued to be satisfactory. The Federal Power Board of Rhodesia and Nyasaland have ordered an additional 60 MVA, 330 kV transformer for the Kariba scheme (Lusaka substation); and the Tennessee Valley Authority placed a contract covering a 200 MVA, 154 kV three-phase bank of transformers and space unit for North Knoxville primary substation.

Among the technical developments of special interest during the year were the production of a new high-speed resistor transition gear for 33 kV. A feature of the year's work has been the successful installation of a " buried " type transformer in conjunction with the South of Scotland Electricity Board. This unit is an air cooled 500 kVA, 11,000/433 volt, three-phase transformer utilising class " C " materials, contained in a strongly protected tank which can be buried directly in the found, for example under a pavement or grass 'verge, with only a small ventilating pillar showing above the surface

Special Article

NATURAL GAS COMES BY SEA

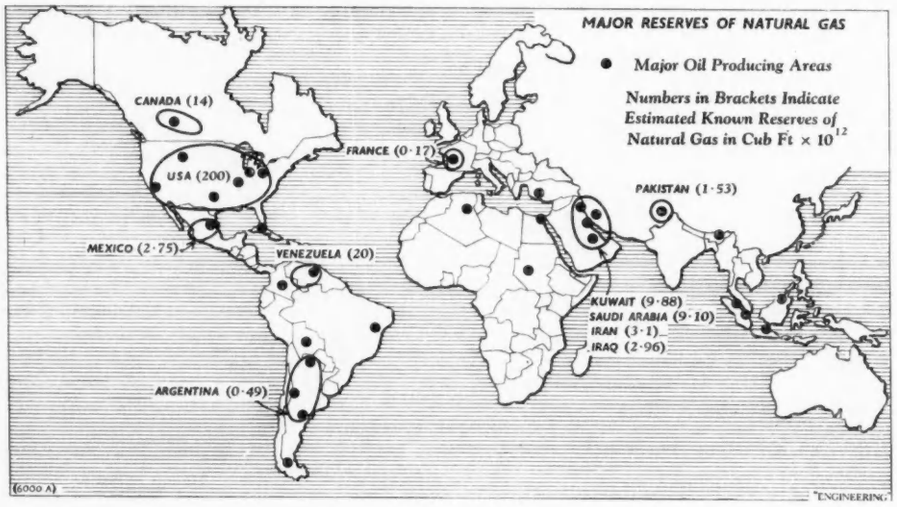
Technical and Economic Feasibility of Liquid Imports

GAS engineers throughout the world are watching Britain as she is about to receive the first load of liquefied natural gas to be transported by ocean tanker. The ship is the Methane Pioneer—formerly the Normarti, of 4,099 gross tonnage, which has been re-equipped with insulated aluminium tanks. Following successful trials on Lake Charles on the Gulf of Mexico, she left there on 31 January with 2,000 tons of liquefied gas, bound for Canvey Island on the north shore of the Thames estuary. Here the methane is being received in two tanks built and owned by the North Thames Gas Board. It will be regasified, piped to neighbouring Romford, reformed to gas of a lower calorific value and then pumped into the domestic mains.

What is Britain's interest in the venture?—financially a half share in a company called British Methane, formed jointly by the Gas Council of Great Britain and Constock International Methane of America. What is the world looking at?—the technical feasibility of transporting liquefied natural gas at − 258° F. Economically it appears sound even on detailed analysis; however in the United Kingdom natural gas could be deemed a silver lining with a cloud, for although such importations promise to be the means of supplementing our gas supplies, of making use of what has till now been flared-off as waste, there are those who fear its repercussions on employment in the coal industry.

Technically the successful crossing is an achievement, particularly in the operation of the vessel itself, but it will be interesting to have a report about the behaviour of the tanks, the stability of the ship at sea and overcoming safety hazards on board, to name but a few of the difficulties. It will need several journeys and experience of rough seas to determine whether ocean transport is really a going proposition.

The development work was done in America where Constock Liquid Methane have liquefaction plant installed on barges for the first step in their projected enterprise of sending liquefied natural gas up the Mississippi to Chicago, and it was because of these facilities that the first cargo came from the Gulf of Mexico.



NATURAL RESERVES

Vast quantities of natural gas exist in the world. In the so-called *dry* reservoirs it is usually at high pressures of around 2,500 lb per sq. in and contains over 90 per cent methane. In *condensate reservoirs* or *wet wells*, 60 to 90 per cent methane is found mixed with propane and butane; when tapped, these wells yield the methane content first. Most of the natural gas in Venezuela and the Middle East is found in solution in crude oil from which it is released as the pressure falls to atmospheric level. The yields obtained from such crudes vary according to the pressure at the well bottom and the composition of the oil. In the case of the Middle East crudes from the high pressure fields the gas yield from the multi-stage separators can vary from 5 to 15 cu. ft per gallon of oil. In the past this gas has been largely flared-off. Precise estimates of the amount of natural gas contained in the crudes has not been made, but one report by the Economic Commission of Europe says that in Venezuela and the Middle East combined, the wasted gas could satisfy the demands for gas in all countries in Europe outside Russia. The wasted output of the Middle East alone, variously stated to be between 500 million and 1,000 million cu. ft per day, could satisfy between half and all Britain's domestic requirements.

The impact of natural gas on the conventional gas-producing industry in America has been enormous, and natural gas now constitutes 97 per cent of the total domestic consumption. The Americans are watching the progress of the Methane Pioneer with interest because the cost of transport by long distance pipeline, which accounts for most of the transportation in the United States, is about 1·5 cents per 1,000 cu. ft of gas per 100 miles, or more than twice the estimated cost of bulk transport by ocean-going tanker at 0·6 cent per 1,000 cu. ft per 100 miles. The advent of ocean-going tankers could alter the pattern of transport of gas, especially to the north-eastern parts of the United States.

In Europe the proposed pipeline between the Middle East and France and London was abandoned only because of the political issues involved, but the French are now considering bringing natural gas over from the Sahara. Since 1950 the consumption of natural gas in the free world outside the United States has increased three and a half times, though in America by only two-thirds. In Western Europe it is expected that the greater contribution to the supplies of gas will come from the recently discovered Lacq oilfields in France.

The exploration for natural gas, which was undertaken in this country by the Gas Council in conjunction with BP Explorations Limited, has been disappointing. Recently, however, a well at Cousland in Midlothian, where the presence of gas was first proved several years ago, has been reopened, and since 28 October, 1957, has been supplying the gas works at Musselburgh, near Edinburgh. This reserve has been estimated as between 2,500 and 3,000 million cu. ft.

LIQUEFACTION AND STORAGE

Existing barges owned by Constock Liquid Methane can handle 8 million cu. ft of natural gas per day. The liquefaction cycle is similar to that used for oxygen—the gas is alternately compressed, cooled and expanded across a turbine, when the chilling causes partial liquefaction. An interesting feature of the plant used by this company is that the compressor turbine is directly coupled to the expander turbine. In taking work from the expanding gas the efficiency of the cooling cycle is increased and 1,200 h.p. is returned to the compressor. Additional gas liquefaction plant, storage and loading facilities is said to be under construction on the Gulf Coast.

The problem of storage, whether immediately after liquefaction or on arrival in, say the United Kingdom, presents some difficulties, for the liquid is at − 258° F. Attempts were made in 1941 to liquefy and store natural gas in Cleveland, USA, but in 1944 a storage tank ruptured with disastrous results. However, a significant conclusion was contained in the statement from the Bureau of Mines Report: "Regardless of the cause of the disaster . . . the application of the system for liquefying and storing large quantities of natural gas is not invalidated, provided proper precautions are observed."

The tank which ruptured was of a vertical cylindrical type having double dished or toro-segmental ends. The inner cylinder was fabricated from low carbon 3½ per cent nickel steel, the outer from mild steel. It is interesting that three other containers fabricated from similar materials, but of spherical design and insulated with cork, not only performed satisfactorily, but were unharmed by the explosion.

Little information is available on the Canvey Island tanks shown in the illustration opposite. They will each hold 1,000 tons of the gas which will be maintained in liquid form by continuous boil-off. Regasification will be made under

" Methane Pioneer " is a fifty-fifty, Gas Council — American enterprise.

pressure by heat exchange with water or steam and, for the present, the cold content will not be made use of. Storage facilities for the methane in the Methane Pioneer consist of five rectangular welded aluminium tanks which each have a capacity for 400 tons of liquefied gas. Insulation is effected by 12 in of laminated balsa wood, interposed between the inner aluminium liner and an outer steel jacket.

CONVERSION

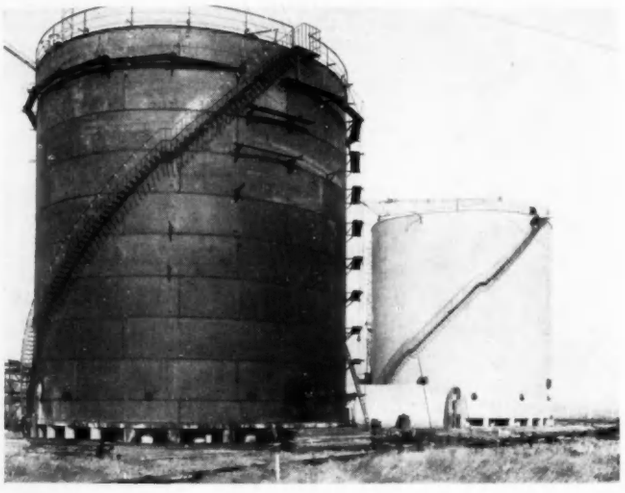
The cargo ship which is now the Methane Pioneer was built in 1945 at Duluth as the refrigerated motorship Marline Hitch, with machinery aft. It was renamed the Don Aurelio in 1951 and prior to conversion was the Normarti, flying the Liberian flag. The latest work on the vessel which, incidentally, is 338 ft 8 in long by 50 ft 4 in beam, was undertaken by J. J. Henry and Company, the New York marine architects, and by the Alabama Dry Dock and Shipbuilding Company of Mobile, Alabama, USA.

The Methane Pioneer has a double bottom and, it is believed, wing tanks to allow special ballasting. One function of the ballast or of a liquid circulation system installed in the double bottom and wing tanks is to ensure that the inner steel plating of the ship's hull which encloses the cold tanks is maintained at the ambient temperature.

The design has to allow for expansion of the tanks if and when they are not containing liquid gas. Furthermore, they must be situated for maximum stability—a troublesome consideration in a vessel carrying a load of such low specific gravity (0·42). Having the machinery aft avoids complications from the passing of the propeller tunnel through the aft holds.

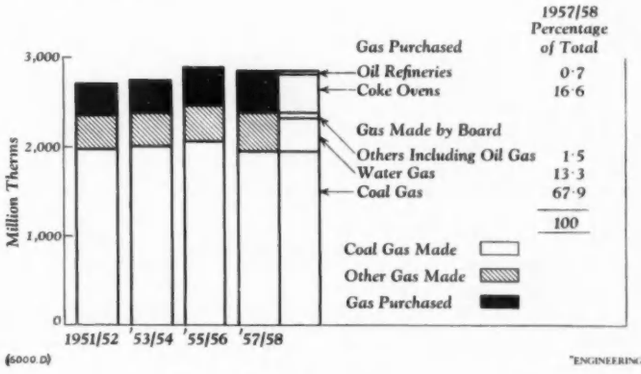
Strict safety measures are enforced in the Methane Pioneer, but basically the handling of liquefied natural gas at atmospheric pressure is safer than of oil: it will not spread over large areas and because it is continuously boiling off—at a rate of about half per cent per day—there is no tendency for the ship's cargo holds to breathe in.

Nevertheless, there is a system for detection and counteraction of leaks in the tanks, piping and fixtures. Strict ventilation of surrounding hold space is enforced and regular inspection is made of the insulation. Though not used in the Methane Pioneer the boil-off could be used as the source of motive fuel.



The liquid cargo of natural gas will be stored in tanks specially built on Canvey Island by the North Thames Gas Board.

The greater part of gas in the United Kingdom is still produced by carbonisation of coal.



ECONOMICS

At the time of the British mission to America in 1951 to study the problem of ocean transport, Mr. Carl Flesher of the International Bank said that he foresaw Middle Eastern natural gas being brought to England for around 50 cents per 1,000 cu. ft, or half the cost of manufactured gas. Another calculation* has indicated that the costs for purification, liquefaction, storage and transportation of natural gas would 4·0*d* to 4·5*d* per therm compared with 3·3*d* per therm for refining storage and transportation of oil.

Although the capital cost in tankers would be greater (£42,000 compared with £20,000 per million therms per year) the cost of gas pretreatment and liquefaction would be less than that of refining oil—£20,000 compared with £30,000 for each million therms. On such a basis it would be more economical to import natural gas than oil if the latter could be bought at the well head for about 1·0*d* per therm less. With the current average price in America of 4·0*d* for oil and 1·5*d* for natural gas this condition is satisfied.

* " Liquid Methane," by J. Burns and L. J. Clark, the Institution of Gas Engineers, Publication No. 484 (1956).

Against this, however, must be set the fact that the calorific value of natural gas is reduced from 530 to 480 therms per ton in reforming, and that the price of natural gas at the well head will undoubtedly increase with greater demand. In the United Kingdom, the comparison with manufactured gas which costs 10-12*d* per therm to put in the gasholder, will still probably remain favourable to natural gas, and the Gas Council suggest that in 10 years time, granted Government approval, the effect on the price of domestic gas, to which the import of natural gas would contribute, could be a reduction of 1*d* a therm, dependant, of course, on the magnitude of imports.

THE FUTURE

The success of the Methane Pioneer brings to a head the whole problem of where Great Britain's supplies of gas are going to come from in the forthcoming years. Traditionally, they came from gas-making coal and carbonisation plant, supplemented in more recent years by small amounts of gas from the coke ovens and from gasification of oil. As is shown in the diagram below at least 98 per cent of our gas is still made from coal.

The large proven coal deposits of low quality have undoubtedly been the main stimuli in the research into complete gasification. In West Fife work on building a plant operating on the German Lurgi process has already commenced. At Partington, a plant costing £2 million is being erected and is expected to come into operation in the 1960's. The process is one of hydrogenation; the first small-scale plant is using oil as the feedstock, but it is anticipated and hoped that the process will be able to cater very economically with low grade coal.

With hydrogenation and the parallel gasification of oil already or fast becoming a reality, the practicability of importing natural gas takes on a different countenance. At the moment one can only conjecture how the country will decide to invest in future methods of producing of obtaining gas. One thing is certain, however, and that is that the Gas Council have found one more string for their bow, and far from being entirely dependent on gas-making coals will now be able to select the one of several processes which proves the most promising at the time of investment. In the light of the policy of the Gas Council to encourage " competition " between the sections of the industry it is not surprising to see them sponsoring the first trials on the transportation of liquid natural gas in the Methane Pioneer.

In the United Kingdom, Europe and indeed in the whole world, the next 20 years should see many interesting developments in gas production.

In Parliament

POOR PUBLIC RELATIONS

A brief, late-night adjournment debate on smokeless fuels took place in the House of Commons last week. Mr. N. N. Dodds (Labour/Co-operative), who raised the subject, said that people were very ready to play their part in a special effort to rid the atmosphere of the smoke which was damaging to health, but they wondered whether all that could be done by the responsible authorities was, in fact, being done. The smokeless fuel mystery was the cause of more irritation among the public than almost anything else he knew.

He referred especially to the lack of supplies, the high prices, which, in some cases, brought up the cost of fuel to as much as £16 a ton; and the poor public relations aspect. Speaking, he said, as a former public relations manager, this aspect of the matter was " appalling."

In his reply, Mr. Reginald Maudling, the Paymaster-General, agreed that the subject was an important one and said that, as such, it was receiving the close attention of Lord Mills, the Minister of Power. The Clean Air Act was based upon the Beaver Report, which estimated that the additional supplies of solid smokeless fuels which would be required over the period of application of the Act would be about 8 million tons suitable for use in open grates. The report had made it clear that a large proportion of that addition would need to be gas coke.

Producers of premium fuels with branded names had been making good progress in their efforts to expand production. The limitations on manufacture were due to the capacity of the plants and to difficulties in obtaining adequate supplies of the rather special qualities of coal required.

STANDARD FOR COKE

Both the Gas Council and the National Coal Board, Mr. Maudling said, had been doing a great deal of work in this field. The Government believed that the Board's new product, now to be known as " Warmco," was a very good one. Output was now commencing at a rate of over 160,000 tons a year and would make a substantial contribution to the problem. If demands warranted, the Board considered that they could transfer some additional coke-oven capacity at reasonably short notice to increasing production.

The main problem was that of supplying gas coke suitable for open grates. Much coke now sold was good-quality open-grate fuel which had been used by many consumers for many years, but this quality of coke was not always available as such. When the Beaver Committee referred to coke, they said clearly that they meant a high-quality free-burning fuel. They recommended that the British Standards Institution should prepare standards and that the gas boards should supply coal to those specications.

Preparation of a British Standard for coke was well advanced and the area gas boards had introduced a draft specification at more than 40 gasworks. The effect would be to avoid marketing unsuitable coke as open-fire fuel, to improve the consistency of delivery to consumers, and generally to make available a suitable gas coke for open-grate burning.

If public demand warranted, it would very soon be possible to supply three million tons, or even five million tons, a year of these qualities.

ONE GIRL TO SIX BOYS

Some interesting figures relating to apprenticeship were given by Mr. Richard Wood, the Parliamentary Secretary to the Ministry of Labour, in reply to Mr. R. Moss (Labour). From these, it appeared that only one girl entered into apprenticeship for every six boys. The numbers of both sexes taking up apprenticeship are, however, again on the increase.

According to his reply, the numbers of boys and girls between 15 and 17 years of age taking up full-time employment for the first time, who entered apprenticeships or learnerships, or employment likely to lead thereto, in each of the five years 1953 to 1957 were as follow:

Year	Boys	Girls
1953	94,400	15,400
1954	88,400	14,800
1955	96,800	15,600
1956	93,200	15,900
1957	95,200	16,800

These figures did not include young persons to whom national insurance cards had already been issued, as a result of holiday or spare-time employment.

Between 1961 and 1965, the average numbers of boys and girls reaching the age of 15 each year would be 35 per cent higher than in 1956, and to maintain the 1956 proportions of those entering skilled occupations would require an increase of a similar order. The desirable rate of increase, however, would vary from one occupation to another. Moreover, not all skilled occupations were entered by way of apprenticeships or learnerships.

VICKERS-ARMSTRONGS SCHEME

Mr. Harold Macmillan, the Prime Minister, told the House that 29 extensions to the Government's industrial factories in the North East Development Area had been authorised in the last few weeks and that one further proposal was still under consideration. There was also, he told Captain E. W. Short (Labour), a considerable amount of privately-financed industrial building in progress, and further work was expected to be put in hand shortly. The 29 building extensions he had referred to would provide work for 2,700 persons, while the 74 privately-financed industrial buildings under construction, totalling some 4·7 million sq. ft of floor space, would create another 1,800 jobs.

In addition, two large schemes were under construction, namely that known as the South Durham scheme and the scheme of Vickers-Armstrongs (Shipbuilders) Limited, which were likely to provide work for some 3,000 employees.

BUSINESS WITH PORTUGAL

There was a perpetual demand to increase trade without regard to ideological differences with the countries concerned, Mr. Macmillan told Mr. Aneurin Bevan (Labour), when some satisfaction was expressed that Mr. Macmillan would not be visiting the British Trade Fair to be held in Lisbon next May. Trade was one thing and ideological points of view might be another.

The President of the Board of Trade, Sir David Eccles, had accepted an invitation to be present at the opening of the fair and, said Mr. Macmillan, he thought it very important that Britain should hold this event. Britain's relations with Portugal were very good and, in 1958, her exports to Portugal had totalled some £22·5 million. He congratulated the Federation of British Industries on their initiative in making arrangements for the fair. Portugal was Britain's oldest ally. By an arrangement made by the Foreign Secretary of a previous British Government, Portugal was a member of NATO.

NOISE IN INDUSTRY

Problems concerning the continuing increase of noise are constantly being brought to the attention of the House. Last week, Mr. H. A. Marquand (Labour) asked the Parliamentary Secretary to the Ministry of Works to give details of any studies into the incidence and effects of noise in factories, workshops and other industrial establishments which had been made by research institutions for which he was responsible.

Speaking in his capacity of representative in the Commons of the Lord President of the Council, Mr. Harmar Nicholls said that the National Physical Laboratory, which came under the Department of Scientific and Industrial Research, undertook surveys of noise for industrial firms. It advised on appropriate treatments to reduce noise inside and outside offices, factories and other places, caused by machinery and equipment in factories and workshops. The Laboratory also carried out fundamental investigations on the " subjective loudness " of different types of noises.

The Building Research Station was conducting a number of surveys related to factory design, construction and use, and the effect of factory noise on neighbouring areas. Several of the research associations, supported by grants from the Department, were also actively in noise abatement, although research was, in most cases, at an early stage. These studies, Mr. Nicholls said, were in addition to those of the Medical Research Council: for instance, on the effect on hearing of exposure to various kinds of industrial noise. Papers on various aspects of the subject had been, and would continue to be, published by HM Stationery Office, as well as in the technical press.

OFFICES IN CENTRAL LONDON

According to an answer given by Mr. Henry Brooke, the Minister of Housing and Local Government, to Mrs. Lena Jeger (Labour), the primary responsibility for granting permission for new office buildings in London rests with the London County Council and not with his ministry. No recent figures were available but, at 31 January, 1956, some 8,334,000 sq. ft of new office space had been provided in the central London area since the termination of the Second World War, and a further 9,877,000 sq. ft were under construction.

Mr. Brooke said he understood that, by mid-1957, the permissions granted for new office buildings in central London amounted to 40,393,000 sq. ft. If all the outstanding permissions were implemented, accommodation could be provided for a total of about 270,000 workpeople. Since, however, some of the new buildings involved the replacement or improvement of existing offices, the net increase in employment in central London would be considerably less than that.

AGRICULTURAL ENGINEERING COLLEGE

Replying to points raised by Mr. H. Ashton (Conservative) about the establishment of a National College of Agricultural Engineering, Mr. Geoffrey Lloyd, the Minister of Education, said that he had now completed his arrangements for the formation of the college. He was glad to inform the House that, after consultation with Mr. John Hare, the Minister of Agriculture, Fisheries and Food, and with representative bodies in the agricultural engineering industry, he had decided to set up a new national college to be devoted to agricultural engineering.

It was proposed to build new premises designed for that purpose at Silsoe in Bedfordshire, near to the National Institute of Agricultural Engineering. He had been assured of the co-operation of the Bedfordshire County Council and, said Mr. Lloyd, he was pleased to report that Sir Eric Ashby, vice-chancellor of Queen's College, Belfast, had accepted his invitation to become the first chairman of the board of governors of the new foundation.

Research on Automation

The Government recognise the importance of promoting research into the development of electronic techniques and equipment, said Mr. J. E. S. Simon, the Financial Secretary to the Treasury. Such investigations, he told Mr. K. Zilliacus (Labour), covered many different scientific activities, towards the cost of which the Exchequer contributes in various ways through the National Research Development Corporation, the Department of Scientific and Industrial Research, the Ministry of Supply, the United Kingdom Atomic Energy Authority and the Admiralty. The work supported by Government funds was being undertaken partly in the Government's own research establishments.

The Human Element

Red Carpetry

The scientific Civil Service is in need of recruits of quality to staff the various research and development establishments operating under the aegis of the Ministry of Supply. Their job is to ensure that "if we ever have to fight another war we shall fight it with the best weapons and equipment that our scientific resources can provide." The type of work—the application and development of advanced techniques in almost every branch of science, mathematics and engineering—and the opportunities that exist for what is defined as "an interesting and rewarding career in the largest research and development organisation in the country" are described in one of the most attractive booklets the Ministry have yet published.

Much trouble has been taken to make the booklet readable and amusing as well as informative. Its title, *An Invitation to Science Graduates*, is in the same direct and friendly style as its contents. The appeal is to both men and women—"equal pay by 1961 and no marriage bar"—and among the attractions offered are good salaries, outstanding working facilities and good prospects for capable people: "we offer you good conditions and interesting work with plenty of leave, and remember, too, that in some fields of research the extensive, and very expensive, equipment and facilities needed are available only in a Government establishment."

With the revision of salary scales (see other note on this page) and the considerable leave granted during the year it is doubtful if any but the most lavish industrial establishments can offer terms more congenial to the young graduate.

Rewards of Public Service

Substantial salary increases for higher civil servants are recommended in the report of the Coleraine Committee published last week. The Government are expected to accept the recommendations and the higher ranks of civil servants will thus receive their first salary increase since 1955. In the scientific Civil Service, the salary of a senior principal scientific officer is raised by £300 a year to £2,400-2,700 and that of a chief scientific officer to £3,400-3,800.

The review of salaries has been carried out by the Standing Advisory Committee on Pay of the Higher Civil Service, of which Lord Coleraine is chairman. The other members appointed to the committee were Sir Oliver Franks, Sir Alexander Fleck, Lord Latham, Sir Geoffrey Crowther, and Sir Alexander Carr-Saunders. The committee have a continuing responsibility "to exercise a general oversight of the remuneration of the higher Civil Service." They were pressed by the staff side of the Civil Service for a review a year ago, but declined to act, to see whether there would be a stabilisation of prices after the measures taken by the Government earlier. The review did not begin until the autumn and has just been completed.

Cost of Learning

The growing popularity of higher education, the "bulge," and the ever mounting cost of learning were the main factors mentioned by the Chancellor of the Exchequer, Mr. Heathcoat Amory, when he announced increases in the Government's financial support of the universities. Grants will be increased by nearly £8 million over the next three years, bringing the total amounts to £39·90 million in 1959-60, £39·35 million in 1960-61, and £42·22 million in 1961-62.

Mr. Amory told Parliament that the University Grants Committee had recommended an increase on two grounds: unexpected increases in student numbers and increases in costs. Both factors were known when the amounts of Government grants were announced at the beginning of the quinquennium 1957-62, but it was not realised that pressure on the universities would develop ahead of the increase in the size of the age groups (due to materialise in the middle of the next decade), because of the tendency for more pupils to remain at school until after 17-plus, and to qualify for admission to the universities.

The committee stated that the number of full-time students at university in 1961-62 would exceed the estimate of 102,000 by at least 6,500 and that the excess would tend to increase in subsequent years. A student population of 124,000 by the mid-1960s, with the possibility of a further 10 per cent increase in the second half of the decade, is now expected.

No Manpower Problems

The Report of the National Joint Advisory Council on restrictive practices called *Practices Impeding the Full and Efficient Use of Manpower* is a curious document in some ways. Its broad conclusion is that industries which have reported to the Council consider that they have no great problems in the efficient use of manpower. With the representatives of the employers, the trade unions and the nationalised industries sitting on the committee which drafted the report, it would be surprising if the conclusion had been otherwise.

The question of efficiency has been related to the establishment or otherwise of joint consultation machinery. While this is certainly something to be encouraged it is by no means an acceptable definition of efficiency. This last must depend on other and more objective criteria.

From 190 industries approached, replies were received from 112 up to the time of analysis, and from these the report calculates that 68 per cent of the employed population in the country were in industries reporting no real difficulty in using manpower efficiently. The "problem" industries numbered six covering 7 per cent of the working population. These six included road haulage, electrical contracting and shipbuilding. The engineering industries as a whole, both sides, have shown a realistic understanding of joint consultation problems in their dealings with the Council. They have refused to lay claim to a facade of cordiality based on consulting machinery.

Winter of Discontent

Owing to fog and frost the unemployment percentage in January reached somewhere near to 2·8 per cent and the Government do not expect it to go any higher. The severity of the winter has made the seasonal increase particularly pronounced but the figure is very close to the official forecast of what it would be back in November. There is therefore nothing surprising even if there is a good deal that is politically dangerous in a figure close to 3 per cent.

There are, however, two other points to consider. First, the unemployment in the development areas is chronically bad. In most localities of any size dependent on heavy engineering, the unemployment percentage is over 4 and this is a sickening reminder that the cyclical problem on Clydeside, in South Wales, in Northern Ireland, and in some other places is still far from solution.

The second consideration is that there may be a significant recovery in industrial output without a corresponding increase in employment. There is likely to be some improvement as the weather improves but it may not be sufficient to pull the unemployment percentage back close to 2 per cent. Two of the worst-hit industries are coal and steel, and neither have slackened their development programmes as the level of unemployment has risen. This is certainly the right long-term policy but it does not help the immediate employment situation.

Stay Alive

Hair raising accounts of accidents, due to the "human factor," and several articles on the safe handling of cranes are contained in the British Iron and Steel Federation's February (No. 4) issue of *Safety*. This is the magazine of accident prevention and industrial health published by the Accident Prevention Committee of the Federation. This issue follows closely on the publication of a technical report *Crane Safety in the Iron and Steel Industry* prepared by a special sub-committee.

The emphasis on the human factor is justified by the fact that of the 1,392 crane accidents which occurred in the iron and steel industry during 1954 and 1955, only 38 were due to the failure of machinery and equipment. How such accidents happen, sometimes due to the carelessness of people not themselves involved, is described, and means of safer operation—including a set of safety rules—are discussed.

In sharp contrast to the steel industry's progress in accident prevention is the rapidly worsening position on British roads. Casualties in 1958 were 9½ per cent higher than in 1957 and included 5,970 people killed. There was a sharp increase in casualties to drivers (other than motor cyclists), both in the numbers killed and injured. The figures went up by nearly 24 per cent, coinciding with an increase of 477,000 in the number of motor vehicles on the road.

Works Outings to the Continent

One of the best things to come out of the Marshall Plan was the systematic attempt to break down the tradition of secrecy in the industry of Western Europe. The American idea that an efficient concern can afford to let others come and see was imported with growing success and the value of the cross-fertilisation of ideas and the rousing of interest in unfamiliar industrial techniques has followed on a growing scale.

A new non-profit making organisation has now been created in Europe to plan inter-factory visits at all levels of industry. Industrial Travel, as it is called, was launched this month as a branch of YTC Universal, which has already arranged holidays for over 50,000 people. Nearly 1,000 concerns in this country have been circulated with details already. The service offered initially covers Holland, Germany, Switzerland, Italy and Luxembourg and the engineering industries are well represented on the list. The immediate plans of the organisation are confined to a scheme to enable employees of British industry to enjoy a week or more on the Continent seeing how others work and live.

Soviet Night School

Young workers in Soviet factories are expected to make great efforts to continue their education. As a result of a law recently approved by the Soviet parliament a new type of school is being intensively developed in all the principal industrial centres. It provides tuition in a wide range of subjects to workers who wish to add to their knowledge and so climb the industrial ladder.

Conditions are not easy and strict discipline is enforced concerning attendance, which amounts to five hours a night on three nights a week. The law stresses the need for ensuring normal conditions of study for the pupils, "by many methods, including the provision for them of a shorter working day or week, with full pay."

Fifteenth and Sixteenth in a Series of Consolidate

RADIATION PROTECTION

By

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THE importance and interest of radiation protection and reactor safety was stressed at the 1958 Geneva Conference by the fact that one of the few general sessions was devoted to operational experience in these subjects.

Records and Experience

The general session opened with a paper (P2263[1]) by the chairman of the International Commission on Radiological Protection, describing the work of this body. The Commission's history was traced back to 1928 when it was entitled the International X-Ray and Radium Protection Commission. It was pointed out that it was the ICRP policy to prepare recommendations on the basic principles of radiation protection, leaving to the various national protection committees the responsibility for the introduction of detailed technical regulations, recommendations, or codes of practice best suited to the needs of their individual countries.

Following this, paper 184[2] from Canada dealt with health and safety in Canadian operations, and from records of film monitoring and bioassay, the conclusion was reached that in general it is possible to handle large amounts of radioactivity without exposing personnel to radiation in excess of 100 m rem per week. Thirteen years ago the authors thought that this would have been considered impossible. A number of papers submitted to the Conference from other countries came to the same conclusion, thus demonstrating the advances in the technique of radiation protection over these years. Mention may be made of paper 302[3] describing radiation exposure experience in the United Kingdom Atomic Energy Authority in 1957 and giving the maximum levels of external exposure to which the Authority works. Health control operations in this organisation involve the collection of very large numbers of measurements of external radiation and also of surface and air contamination, with the addition in a smaller number of cases of urine analyses for a variety of individual radioactive substances.

Permissible Levels and Control

The biological background to the recommended maximum permissible levels of radiation was stressed in numerous papers describing the biological effects of radiation in animals, such as ageing and genetic effects, the production of leukaemias or cancers; some rather tentative approaches to the treatment of radiation-induced disease were also described. A more cheerful note was struck by a survey of the expectation of life and cancer mortality of British radiologists since 1897; evidence was adduced in this paper that radiologists who started radiology since 1920 may not have incurred any appreciable hazard, though it was stated that final judgment of the efficacy of the protective measures employed by them should await the outcome of a longer period of observation. Although some papers demonstrated certain biological facts at rather low doses of radiation, the trend was to give very definite support to the basic maximum permissible levels now being used.

In the sessions on experience in radiological protection, further examples were given of the control methods required for specific hazardous substances. Paper 760[4] from the United States, for instance, described the control of health hazards in handling plutonium, which may be cited as a good example of the methods developed for the handling of substances of the highest toxicity. A further paper, from Los Alamos, described the recent developments in facilities for handling intense alpha sources; in these very complex facilities, emphasis was laid on the importance of transfer mechanisms from enclosures into operating areas. In a similar vein much information is given in paper 1459[5] on the somewhat elaborate types of shielded enclosures used in the United Kingdom for physical and metallurgical examinations of reactor fuel elements and test loops.

Handling Toxic Materials

Uranium is much less difficult to handle than plutonium but is still toxic compared with most ordinary metals. Its safe handling in industrial practice in the United Kingdom was described in a further paper from Springfields factory. Here as in most atomic energy work, means of eliminating radioactive dust is one of the main essentials in radiation protection and " although the works has many problems associated with high gamma radiation, it has a multitude of smaller problems, each of which requires close attention by technical staff to ensure that an adequate answer is obtained." This statement, concerning the great number of small problems to which basic principles have to be applied, is borne out in many papers, and indeed supplies the very real interest associated with so-called routine radiation protection work. A paper from the United States described radiation protection services in a large industrial corporation with many individual factories, the majority of which have relatively few radiation workers; this requires a somewhat different type of organisation from atomic energy establishments. Comparatively few radiation protection workers were employed, but it was pointed out that a good deal of outside advice was obtained and most of the operations were of a routine nature and were therefore rather easily controlled.

It is sometimes difficult to assess the relative hazards of working with different radioactive nuclides purely from information concerning their maximum permissible concentrations in terms of microcuries of element per cubic centimetre of air. In working practice some elements may more easily produce an air-borne hazard because, for instance, of their higher activity per gram weight. Such problems as these are discussed in a paper from France (P331[6]).

Instrumentation

Turning to the instrument field, one of the notable developments since the last Geneva Conference has been the much increased interest in the application of gamma spectrometry to health physics problems. Many papers concerned with radiation measurement were in this field and it was clear that a most important advance has been made. The amount of gamma-emitting isotopes in the human body can be assessed with some confidence by a whole body counter using this technique, thus providing a more accurate estimate of any body burden of such isotopes than urinary analysis. Similarly beta activity in the body may be estimated from the *bremsstrahlung* emitted, though not at such low levels. A problem which might present great difficulty by ordinary techniques is the detection of plutonium embedded in a skin scratch. A paper from the USA and another from Britain showed that the gamma spectrometric method can detect plutonium in surprisingly small quantities from the very soft X-rays emitted by 4 per cent of disintegrations. In this way plutonium can be detected at depths below the skin much greater than the range of alpha particles. Further progress was also shown in the dosimetry in the lung of airborne radioactivity especially of the decay

GENEVA DISTILLATE

Prolific in papers and enormous in scope, the Second International Conference on the Peaceful Uses of Atomic Energy can only assume its true significance when the information presented there has been thoroughly digested. As a stage in this process, ENGINEERING has commissioned sixteen specialists to summarise the matter of the Conference under a number of subject headings. The process may be regarded as one of distillation, with concentrated fractions drawn off at various levels. The contributors have consolidated the information published during the Conference, selecting the essentials, reconciling the submissions of different authors and countries, and tabulating the most important data. As an introduction to the series, we published on 19 September Sir John Cockcroft's overall survey of the Conference. The present series has been published at weekly intervals and includes sixteen articles in accordance with the table. The Conference was held in Geneva from 1 to 13 September.

Power Reactors (28 Nov., page 694) ..	Mr. G. W. K. Ford, Research Manager, Dounreay
Research Reactors (21 Nov., page 662)	Dr. V. S. Crocker, Reactor Division, Harwell
Thermonuclear Research: (Pinch Effect) (19 Dec., page 796)	Dr. A. A. Ware, AEI Research Laboratory
(Other Devices) (26 Dec., page 824)	Dr. R. J. Bickerton, Controlled Thermonuclear Research Division, Harwell
Propulsion .. (7 Nov., page 600)	Mr. B. T. Price, Reactor Division, Harwell
Radiation Shielding (31 Oct., page 568)	Mr. J. D. Jones, Reactor Division, Harwell
Reactor Engineering (5 Dec., page 730)	Mr. R. P. Kinsey, Chief Engineer, Advanced Reactor Design Office, Risley
Metallurgy and Fuels (23 Jan., page 106 and 30 Jan., page 136)	Mr. L. M. Wyatt, Technical Manager, Risley
Instrumentation (12 Dec., page 762)	Mr. R. B. Stephens, Mullard Equipment Ltd.
Nuclear Physics (24 Oct., page 536)	Dr. M. J. Poole, Nuclear Physics Division, Harwell Dr. M. Sowerby, Nuclear Physics Division, Harwell
Radioactive Isotopes (14 Nov., page 634)	Mr. E. R. Wiblin, Isotope Division, Harwell
Isotope Separation	Mr. F. I. Hurley, Head of Laboratories, Capenhurst
Chemical Processing (6 Feb., page 172)	Dr. R. Hurst, Director, Dounreay
Radiation Protection	Dr. I. S. Eve, Radiobiological Adviser, Health and Safety Branch
Reactor Safety	Mr. F. R. Farmer, Head of Reactor Safety Division, H & S Branch

products of radon and thoron which have always posed some rather complex biophysical problems.

Waste Disposal

A considerable number of papers were devoted to radioactive waste disposal and the interpretation of what happens to radioactive elements dispersed in the human environment. The depths of the sea have often been suggested as a suitable place to dispose of radioactive wastes and a paper from the USSR surveyed the possibility of dumping large quantities of radioactive wastes in containers into the great depths of the ocean. If there was only a very slow turn-over of water from the depths to the surface, this might be considered to be a satisfactory method of dealing with wastes. The USSR paper put forward evidence from the distribution of oxygen and phosphate in some of the deepest parts of the sea that there was a considerable turn-over between the depths and the surface and that therefore these sites were unsuitable for waste disposal.

A paper on mixing mechanisms in the oceans from the USA indicated that owing to movement of living organisms, estimates of vertical transport of radioisotopes in the ocean based upon physical conditions alone may be in error by a factor of two or more. Much further research was, however, needed as is demonstrated by the opinion of Revelle (USA) that radioactive materials introduced into the deep ocean water "will be partially isolated from the upper mixed layer for at least several decades and perhaps for several hundred years." "The depths of the sea are thus the only place in the ocean where we can now be confident that radioactive wastes of the order of some tons of fission products a year can be safely deposited."

The position is of course entirely different in radioactive waste disposal of relatively small and controlled amounts of dilute material from pipe lines into the sea, such as is discussed in two papers from the United Kingdom (P296[7] and P297[8]) on sea disposal of low-activity effluent. It must be distinguished also from the disposal of containers containing relatively small quantities of radioactive waste into the sea, since in this case even if the container bursts such an amount of radioactivity would be easily diluted.

As in the 1955 Geneva Conference a number of papers dealt with the possibility of disposal of radioactive wastes by distributing them in an insoluble medium. A paper from Canada explores the possibility of disposal of fission products in glass. A paper from Oak Ridge (P1073[9]) also surveys most of the suggested methods, including those in which strontium 90 and caesium 137 are removed for subsequent use. The authors come to the conclusion that ultimate disposal methods are as yet largely speculative, although they acknowledge that preliminary work has been done. Paper 389[10] gives the experience of Hanford Works in waste storage in tanks; the authors state that "at present and for many years in the future, the storage of radioactive waste liquids underground in metal containers is an economical and safe method," although it was also stated that the ultimate life of tanks is unknown and tank storage is considered an interim method of waste disposal.

In the disposal of gaseous wastes there are problems of meteorological interest and also possibilities of research into air movements, which were surveyed in a paper from the World Meteorological Organisation.

Environmental Aspects

There were numerous papers also on the behaviour of specific isotopes, particularly strontium and iodine, resulting from air-borne contamination. Investigations were recorded of the mechanisms by which these elements were deposited in the soil or on leaves or taken up into the structure of human or animal food plants, and their appearance in milk. Also of importance in the consideration of strontium distribution was the influence of calcium in the soil. It was seen that emphasis in this Geneva Conference was rather more on such public health aspects of radiation protection than many of the now more conventional occupational aspects. Of especial interest in the United Kingdom was paper 316[11] reporting the elaborate environmental survey of radioactivity levels after the reactor incident at Windscale in October, 1957. A notable feature of the Conference was the full and frank discussion of actual radiation exposures experienced and the results of this policy led to the accumulation of a great deal of very reassuring information.

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REACTOR SAFETY

By
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THE two sessions allocated to reactor safety covered in the main those matters which are common to many types of reactor and problems which are likely to be common to very many countries. These include the organisation for hazard evaluation and inspection in Paper 2407,[1] and United States experience in reactor operation and reactor safeguards in P1551.[2]

The legal problems of national and international significance are reviewed in P2352.[3] The principles for dealing with safety administratively and by location in Sweden are described in P173.[4] Other papers dealing with siting, release of fission products and containment also appeared in the reactor safety sessions, but these form only a small part of the subject matter of interest to students of reactor safety.

There is a wealth of information available spread out among the large number of papers submitted to the Conference covering the more detailed interests of reactor safety, as in the physics of reactor cores, the dynamic behaviour of reactors, the accumulation of operating experience, the behaviour of fuel elements, the reactions between reactor materials and the use of safety fuses.

It is impossible to review all the detailed information presented, but the reader may be assisted by a reference to some of the papers which have a significant bearing on the safe design and operation and location of reactors.

Operating Experience

The accumulation of operating experience is well brought out by a number of excellent summaries, notably P1132[5], describing the operating experience of the French reactor G1; P2183[6], P2184[7] and P2185[8] presented by the USSR; P1518[9] and P1522[10] covering Windscale and Calder Hall respectively, and P1524,[11] experience of the DIDO research reactor. USA experience is covered in a number of general papers, such as P1075,[12] giving a review of the experience of the nuclear power reactors, and in addition a number of papers give research reactor experience—P1923[13] the Vallecitos BWR P2177[14] quoting the operating experience, including the minor troubles on MTR and ETR; P418[15]—a 10 kW research reactor and P1034[16]—experience with special cores in the MTR, and P422[17] covering experience in the operation of a 1 kW research reactor.

The report of the Windscale accident, dealing mainly with the site surveys, is given in P316[18] and there are a number of excellent reports on the examination and theoretical studies associated with EBR melt-down in papers 1892[19], 2437,[20] 1462[21] and 2156.[22] Paper 418[15] gives an interesting account of the number of small troubles which arose during the commissioning of a 10 kW research reactor, and also tabulates the effort required by qualified staff in modification and maintenance, and on health-physics monitoring and supervision. This requirement of a strong team adequately trained in physics and engineering and radiation safety to be associated with the development of research reactors is also supported by P 1524[11] and 2177.[14]

Whilst the papers of the 1958 Conference bring out the substantial increase in the understanding of reactor systems through operation experience, they also show an increasing awareness of the complexity of reactor systems and the need to understand each reactor in great detail. This is particularly well brought out in the field of water-moderated reactors for which a large number of papers have been presented, reporting on theoretical and experimental work in the dynamic behaviour of the reactor, and the physics of the core assembly. USSR papers 2144[23] and 2186[24] report theoretical and experimental work on heat transfer and self-regulation of water reactors. The experimental work on the United States SPERT is reported in paper 2428[25] and other studies in papers 1079[26], 1845[27] and 2402.[28]

All of these papers lead to the conclusion that the well designed conservatively rated water reactor can be a very safe reactor, provided that

Continuing

Reactor Safety

the detailed operating characteristics have been fully explored. This includes an understanding of the dependence of reactivity with geometrical variations in the core layout and on water displacements taken either uniformly or at selected places in the core. Studies on particular assemblies are reported in papers 1019[29], 2428[25] and 2469.[30] An appreciation of problems in heat transfer and problems in core design affecting reactivity coefficients through varying uranium/hydrogen ratios is set out in the USSR paper 2184[7], which reports on the water-cooled power reactor.

It is interesting to note how the need for economy in design and operation is leading to the acceptance of higher heat-transfer rates which have been introduced only after prolonged experimental work has been carried out on a particular reactor system. As the margin between the operating condition and the burn-out heat flux is narrowed, greater attention in detail is required in the design of the fuel element, in order that it should remain free from distortion and retain its heat-transfer properties. More detailed attention is required to the variation in flow from point to point and variation in neutron flux, particularly near special voidages and experimental facilities.

The operating experience and supporting experimental work in the gas-cooled reactor field is not so extensively covered, but is reported in paper 267.[31]

Irradiation Effects and Fission Product Release

Various papers deal with the reactions that take place under irradiation, and with the fission-product release from fuels. The decomposition of water is of obvious importance in the safe operation and control of water reactors, and is well covered in papers 946[32] and 1551.[3] The growth of corrosion products in the PWR is reported in paper 410,[33] and the UK paper 2485[34] gives an excellent summary of the stored energy problem in graphite. There are a number of papers dealing with the irradiation damage of metals, reporting both experimental work and derivations of recent theory. There is a general review in the USA paper 1978[35] and some basic work reported in paper 2385.[36] The UK paper 87[37] covers some investigations of damage to zirconium, molybdenum, tungsten, copper and nickel, as well as steels. The paper 190[38] from Canada reports on radiation damage to ferretic steels.

Some aspects of the behaviour of fuel elements under irradiation and at various temperatures is reported in a number of papers, but cannot be adequately covered by a brief review. Reference is made to the USA paper 1074[39] and the UK paper 81,[40] and the use of burst-cartridge detection gear is reported in the French paper 334[41] and the UK paper 57.[42]

Shut Down and Safety Devices

Interest in a safety fuse to give further protection to reactors is still evident, although no general or perfect solution to the problem has yet been found. USA experience is reviewed in paper 1080[43] which indicates that some systems are now promising though not fully tested. Paper 1019[29] refers to nitrogen-gas injection as an additional shut-down device, but there is no indication of the reliability or effectiveness of this method under service conditions. Paper 1038[44] reports the use of boric acid injection in the Yankee atomic plant, although this requires the manual starting of high-pressure pumps.

Containment

A careful search through the Geneva papers is required to obtain a comprehensive picture of the part that containment now plays in the achievement of reactor safety. It is clear that containment properly designed, plays an important part in adding to the safe development of reactors when taken in conjunction with a number of other factors. These factors include the available operating experience, the information obtained from a related research programme, the class of reactor and its location. The USA paper 1879[45] gives an excellent summary of the majority of the world's reactors and indicates the containment now provided. Paper 172[46] from Sweden and paper 561[47] from Norway show that containment in rock structure can be useful in some locations. The advantages and disadvantages of underground containment are well reviewed. It is shown that the underground rock cavern provides an excellent pressure envelope, but still requires steel lining. Particular attention to the adjacent water table is required and crack filling by cement injection may be necessary, combined with soil cover over the rockbed, to provide effective filtration for any fission-product release. The provision of steel shells around reactors with discussion on problems of specification, design and testing is described in more detail in paper 1891[48] for the EBWR and paper 1892[19] for the EBR-II. Paper 1028[49] suggests that scale-model tests can be of value in some cases.

Paper 435[50] gives an excellent theoretical and graphical presentation of the shielding thickness required around the container to reduce radiation levels on a reactor site after an accidental release of fission products into the container.

The new problems of containment for a marine reactor are explored in paper 1023,[51] which gives a description of the containment to be provided on the N.S. Savannah. The reactor containment is protected externally from collision by timber and reinforced concrete, and the container is surrounded by a substantial thickness of lead to reduce radiation from the container under accident conditions. The possible spread of contamination from the primary water system of the USSR icebreaker and the methods of establishing adequate safeguards for personnel protection are discussed in paper 2518.[52]

It is noteworthy that a number of recent reactors are not contained. The attempt to confine a reactor incident by the controlled and filtered ventilation of a well constructed building is reported in relation to the ETR in paper 414,[53] and reference to the Oak Ridge Research Reactor confinement is made in paper 1551.[2] This seems to be a logical development following the increase in knowledge of reactor response to normal and abnormal conditions, together with supporting information on the fission product release from fuel elements, and their subsequent dispersion under accident conditions and the effects of their release on the environment.

Atomic Review

Independent Variable

FUEL may justly be regarded as the independent variable of reactor design. From the characteristics of a fuel, from the extent to which it can endure high temperatures, corrosive atmospheres and irradiation, from the ease with which it can be processed and refabricated, from these determining factors all else follows—feasibility, design, and economics of operation. The first part of Atomic Review is concerned with a new plant for fuel processing; the second with the high temperature reactors that have been made possible by the development and manufacture of advanced fuel elements. High-temperature fuels were discussed in Atomic Review last 26 December.

Competitive Fuel Rods from UKAEA

The Springfields Works of the UKAEA has recently opened its front doors and allowed its production processes to be inspected. Its vastly expanded capacity will enable the Authority to supply the civil requirements of canned uranium fuel rods, and has so far cost about £12 million in capital expenditure. Sir William Cook, member of the Authority for engineering and production, said that although the UKAEA was at present the only manufacturer of fuel rods in this country, he thought it quite possible that work of such kind might be undertaken by industry, and further, that the aim at Springfields was to make rods which would compete with all-comers both at home and abroad. Up to the present all rods for Windscale, Calder Hall, Chapel Cross and BE[illegible] have come from this factory and about a milli[illegible] canned rods have been made to date.

Improved Processing of Uranium

The main innovation at Springfields has be[illegible] an increase in the capacity for extracting uraniu[illegible] from the ore, and in completely new proce[illegible] lines for converting the metal into the accurate[illegible] finished fuel rods. Great effort has been ma[illegible] to increase the throughput of the canning line[illegible] where scrupulous cleanliness has to be combine[illegible] with tolerances of only thousandths of an inch[illegible] when permanently sealing the rods into the[illegible] magnesium alloy cans. Six canning lines ar[illegible] being prepared, the first of which will b[illegible] exclusively for Calder Hall and Chapel Cros[illegible] and was due to start production by the end of la[illegible] month. Another is primarily intended fo[illegible] experimental rods, and the other four lines ar[illegible] intended for the consortia of firms who ar[illegible] building the four civil reactors at Berkeley[illegible] Bradwell, Hunterston and Hinkley Point. Sir[illegible] William added that even further expansion would[illegible] be required if they were asked to supply the[illegible] rods for reactors such as would undoubtedly b[illegible] built overseas, but in the present state of affair[illegible] it was possible to set up the necessary fue[illegible] production lines in a shorter time than wa[illegible] required to design and build the reactor for[illegible] which they were intended. The increase i[illegible] capacity at Springfields does not mean that fue[illegible] rods will be produced more cheaply, but rather

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that the Authority will continue to be in a position to satisfy the demand for many different designs while maintaining the cost at about £20,000 to £22,000 a ton.

Beryllium Cans

Among the other research projects being undertaken at Springfields is one on the development of beryllium for cans, which it is planned should be used in the advanced gas-cooled reactor now under construction at Windscale. Although the metal has promising properties for operation at higher temperatures—its melting point is 1,284° C as compared with 660° C for aluminium and 650° C for magnesium, it is difficult to fabricate because of its brittleness at low temperatures and its toxicity at elevated temperatures. Further work on beryllium is being undertaken by ICI who recently committed themselves to investment in a £1·5 to £2 million small-scale factory with the primary aim of supplying metal cans to the UKAEA.

Better Designs with BICEP

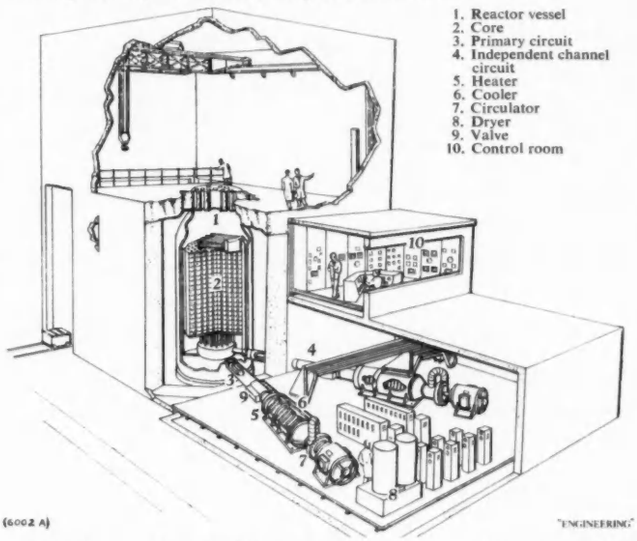
Special rods are being made for BICEP, the British Industrial Collaborative Experimental Pile, which exists to enable research on reactor and rod design to be undertaken for the British Consortia and for the Central Electricity Generating Board. If this research results in a recommendation of a standard design of rod, it should be possible to use the Springfields facilities to even better advantage. The new works allows rods with up to twice the normal concentration of uranium 235 to be made with no danger of criticality, but the Authority has avoided production of more highly enriched rods at Springfields in the interest of complete safety, for which reason the fuel elements for the fast reactor and for the test reactors DIDO, PLUTO and DMTR are made at Dounreay.

Towards Higher Temparatures

DRAGON: Co-operative HTGC Prototype

The prototype high-temperature gas-cooled reactor project to be undertaken jointly under the auspices of the Organisation of European Economic Co-operation (OEEC) has been formally approved at a meeting of the OEEC's European Nuclear Energy Agency. To be known as DRAGON, the reactor project is to be based at Winfrith Heath and will cost £13·6 million over a period of 5 years. The 12 nations concerned are Britain, the six members of Euratom, and Austria Denmark, Norway, Sweden and Switzerland; Britain and Euratom will each contribute £4·34 million, the other five countries £1·32 million, and the balance of £3·6 million will be met by Britain, who will retain the reactor and associated equipment. Reference to this project has appeared in Atomic Review on 8 August, 1958, and a full description of a proposed 10 MW HTGC design was published under the title " British Reactor of the Future," last 12 September (page 336). The high-temperature system was first discussed in ENGINEERING, vol. 182, 1956, p. 725.

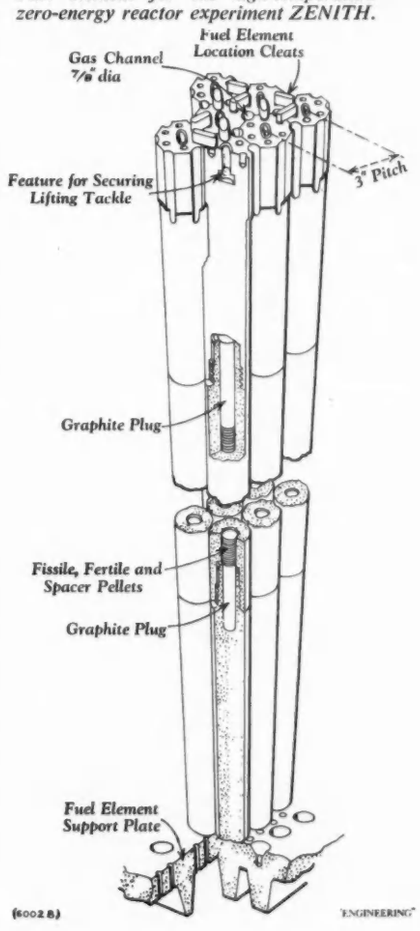
Arrangement of the advanced experimental reactor HERO.



ZENITH

At present a zero-energy experiment designed to provide information on core design for HTGC reactors is nearing completion at Winfrith Heath. Known as ZENITH or HTZER (High Temperature Zero Energy Reactor), it has been built for the UKAEA by the General Electric Company and is due to diverge in 3 or 4 months. The 10 MW prototype will be designed in the light of the results obtained from this reactor. Fuel temperatures up to 1,300° C are anticipated and a gas outlet temperature of 750° C. The layout of the reactor was illustrated in Atomic Review last 5 September and a fuel element is shown below.

Fuel element for the high-temperature zero-energy reactor experiment ZENITH.



ZENITH Data

Core height less reflector: 4 ft
Core diameter less reflector: 4 ft
Height over reflector: 8 ft
Diameter over reflector: 10 ft 6 in nominal
Weight of reflector: 26 tons
Thermal - radiation barrier (between core and reflector): lampblack
Fuel elements: enriched uranium and thorium ceramic discs with graphite spacer discs inside graphite tubes
Moderator: graphite of the fuel-element tubes
Number of fuel elements in core: 235
Maximum thermal-neutron flux: 10^8 neutrons per sq. cm per sec
Maximum power: 100 watts
Lattice pitch: 3 in triangular
Control: by neutron-absorbing rods at the inner edge of the reflector
Heating and cooling medium: nitrogen
Gas inlet temperature to heater: 400° C maximum
Gas outlet temperature from heater: 950° C maximum
Normal maximum working gas flow: 3,000 lb per hour
Cooling-down gas flow: 10,000 lb per hour
Working gas pressure: 18 in water gauge
Cooling-down time: 48 hours
Heating-up time: 48 hours

Impermeable Graphite for Hot Fuels

The HTGC system involves the dispersal of a ceramic fuel in a graphite moderator (though a beryllium moderator has also been proposed). If the escape of fission products is to be minimised, the graphite must be impermeable to the gas (helium, or possibly nitrogen) at the temperatures involved, and various organisations have been working on the development of an impermeable graphite. (Reference to GEC work appeared in Atomic Review last 15 August and to Hawker Siddeley studies on 26 December.) It is now reported that an impermeable graphite has been produced on a laboratory scale by a two-stage process at the Royal Aircraft Establishment, Farnborough. The design of fuel elements based on this principle has been described in ENGINEERING last 12 September (page 336) and last 30 January (pages 140 and 141).

More about HERO

As reported in Atomic Review last week, HERO (Hot Experimental Reactor Zero Energy) is to be built at Windscale to complement work on the AGR (Advanced Gas-cooled Reactor), and its arrangement is shown in the sketch above. It will be used for low radiation level measurements and for investigating alternative arrangements of fuel.

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Continuing Atomic Review

Windscale is to be one of the national centres for the development of gas-cooled reactors. HERO will be completed early in 1961 and will be operated and studied by physicists of the Research and Development Branch at the Windscale laboratories. The graphite core will be contained in a steel vessel connected to a pipe circuit with pumps and heaters so that it can be operated at high temperature in carbon dioxide. The carbon dioxide gas will supply heat to the core instead of removing heat from it. The fuel will consist as in the AGR of clusters of pencil-like rods of uranium oxide sealed into beryllium cans, and these will be arranged in channels in the graphite on a regular lattice.

Notes and News

Rolls-Royce Nuclear Company

Set up to carry on a wide range of nuclear activities, Rolls-Royce and Associates have been registered as a private company with a nominal capital of £250,000 in £1 shares. Vickers and Foster Wheeler will each hold 24 per cent of the shares, and Rolls-Royce the remaining 52 per cent. The new company is complementary to Vickers Nuclear Engineering (see ENGINEERING, vol. 181, 1956, p. 220 and Atomic Review last 16 May), in which Rolls-Royce and Foster Wheeler also have an interest. Both associations are interested in nuclear propulsion and in particular are concerned in the construction of nuclear powered submarine HMS Dreadnought.

State Settlement of Excess Insurance Claims

Under the Government's proposed new licensing bill, it is understood that absolute liability is to be covered in the event of any claim involving nuclear energy. But, since an operator cannot be expected to meet claims in excess of £5 million or those arising after 10 years, such claims up to 30 years after an accident would be referred to Parliament for settlement by the State.

Marine Survey for Sizewell Station

All preliminary marine survey work for the proposed sixth nuclear power station at Sizewell, Suffolk, was undertaken by the Contract Survey Department of Kelvin and Hughes (Marine) Limited. Surveys were undertaken in connection with harbour facilities, feed-water intake and exhaust and other requirements, on the instructions of Mouchel and Partners, consulting construction engineers, on behalf of the Central Electricity Generating Board. With a planned capacity of 650 MW, Sizewell is the largest projected nuclear power station in the United Kingdom.

Other United Kingdom nuclear power stations at which the Kelvin Hughes Contract Survey Department has conducted marine surveys are: Bradwell, Essex; Berkeley, Gloucestershire; Hinkley Point, Somerset; and Hunterston, Ayrshire. Complementary work was also carried out by this organisation at Port Madoc, Caernarvonshire, in connection with the power station in North Wales.

Winfrith Heath

The UKAEA state that according to current plans, the programme of fission reactor development alone will result in an establishment at Winfrith Heath of between 2,000 and 3,000 people by 1962.

Automobile Engineering

By Gordon Wilkins

LOTUS PROGRAMME

Sports Car Racing to Concentrate on Formula 1 and 2

PROFITING from the lessons of 1958, when they attempted to do too much and suffered in racing, Lotus have pulled their works team out of sports car racing but will give limited support to approved stables and private owners. The bounding vitality of this vigorous young outfit will now be concentrated on production of an extended range of cars, including a new small sports model, and full scale participation in Formula 1 and Formula 2 Grand Prix races with five cars.

Drivers in Formula 1 will be Mr. Graham Hill and possibly Mr. Keith Hall, and in Formula 2 Mr. Innes Ireland and Mr. Allan Stacey. The single-seater which takes either size of engine has been redesigned with a new chassis frame and cleaner body which has no blisters over the engine. For Formula 1 events a new Coventry Climax unit with redesigned crankcase, new crankshaft and swept volume raised to 2,495 cc will be employed. After experiments with two different mountings, the power unit is canted at 17° to the vertical and 10° to the car's horizontal centre line to take the drive shaft past the left side of the cockpit. The Lotus 5-speed gearbox in unit with the differential has been redesigned with a positive stop shift in which the lever returns to the same position every time instead of the five-notch quadrant which drivers found difficult to use. There is now more room in the cockpit, and the exhaust system is mounted externally. Cooling systems for water and oil are redesigned and the rear suspension is stronger. The new frame has a removable tube over the engine for additional stiffness, and the suspension at front and rear is partly enclosed by the body. The car weighs about 700 lb dry.

Using the car in Formula 2 form with 1,500 cc Climax engine, Graham Hill has already lapped the Brands Hatch circuit in 56·3 seconds and put in 15 consecutive laps below Stirling Moss's record of 57·4 seconds.

The entirely new sports racing car is the Seventeen. Conceived originally as a 750 cc machine, it is very small and extremely light and, as now offered with the Climax 1,100 cc engine, will be very potent indeed. At present it is only being supplied on the British market.

The Lotus Eleven Le Mans, which is homologated for competition under Appendix J of the International Sporting Code, is still listed, and two other models with similar bodywork, the Lotus Eleven sports and Lotus Eleven Club, which have rigid rear axles, can also be supplied to order.

The Seventeen is much smaller, with a wheelbase of 83 in, and a lower frontal area. It weighs 110 lb less than the Lotus Eleven. Suspension is all independent with a new strut type front suspension which beats even Lotus records for lightness. A coil spring and damper strut acts as the steering swivel, and has a light tubular stub axle, with mounting plate for the disc brake caliper and the steering arm, attached at the base by four bolts. The top end of the strut is attached to the frame; the lower end rests on a single wishbone. Rear suspension is the Lotus strut-type swing axle as on the single seaters, the Fifteen and the Elite. The widely separated mounting points of the suspension have permitted the creation of a strong but extremely light space frame. The sheet metal floor is a stressed unit, and a small sheet metal drive-shaft tunnel takes part of the braking and acceleration loads from the chassis-mounted differential. A light alloy fuel tank of 8 gallons is mounted at the rear.

The engine normally supplied is the Coventry Climax 1100 with single overhead camshaft in Stage III tune with five bearing crankshaft giving 84 b.h.p. at 6,800 r.p.m. on a 9·8 to 1 compression. Mounting points are also designed to take the Climax 750 cc FWM engine when it becomes available.

Transmission is through a 7¼ in single plate clutch, hydraulically operated, and a lightweight four-speed close ratio gearbox in unit with the engine. A choice of four ratios is available for the hypoid final drive and a ZF limited slip differential is an optional extra. Bolt-on disc wheels in cast magnesium are used as they save 35 lb of unsprung weight, compared with centre lock wire wheels. Brakes are Girling discs of 9½ in diameter, operated through two master cylinders with an adjustable balance bar. The body will be very well streamlined on familiar Lotus lines. Dry weight is only 750 lb for the complete car.

The Lotus Fifteen already raced so successfully by private owners has been refined and developed. The 1,100 cc Climax engine in the Lotus Fifteen is delivered in Stage III tune. This has a five-bearing camshaft to overcome the camshaft flutter experienced at high revs with the previous shaft, but the crankshaft on all versions of this engine runs in three copper lead bearings. Apart from the five-bearing camshaft, other modifications on the Stage III engine include stronger valves and valve springs, high compression head with 0·040 in removed to give a 10·5:1 compression ratio. The tops of the pistons are scalloped to clear the valves. These modifications now permit a maximum gross power of 90 b.h.p. at 7,200 r.p.m. and maximum torque of 71 lb-ft at 5,200 r.p.m. The carburettors are two single choke SU of 1½ in choke diameter. Turning circle for this car is 39 ft and road speed in top gear at 1,000 r.p.m. with the 4·55:1 axle ratio is 16·7 m.p.h. (26·87 k.m.h.).

A four-speed BMC gearbox is now fitted in unit with the engine. The same box will also be available to export buyers of the 1500 car as they may find it easier to service than the Lotus five-speed box which forms a unit with the differential, although this is still available to order.

The low body-line does not allow a conventional radiator heater tank to have a sufficient head of water above the pump to separate air bubbles and prevent cavitation at the impeller in all conditions. Two swirl pots are therefore being used to separate the air by centrifugal action and allow the water displaced by thermal expansion to be returned again on cooling.

Comparison of the new strut type front suspension with the old divided axle suspension used on the first Lotus models shows a certain similarity, but the new layout gives a front roll centre only 2 in above the ground, compared with 6 in on the divided axle type used on the Lotus Eleven. Despite streamlined bodywork partly enclosing the wheels, the Seventeen will have a turning circle of 39 ft. The chassis frame weighs only 41 lb complete with mounting brackets. Mr. Frank Costin having joined Lister as full-time designer, body shape for the Seventeen was created by Mr. Len Terry and the Lotus design staff. The frontal area is only 9 sq. ft.

The Lotus Elite, now in regular production, will be raced at Sebring, Le Mans, and Rheims. For the Fomula 1 and Formula 2 cars, Stan Elsworth, former Vanwall mechanic, will take charge of preparation. Dimensions: wheelbase 82 in (208·5 cm.). Front track, 42 in (108·7 cm.) Rear track, 45 in (114·3 cm.). Overall length, 131 in (332·7 cm.). Overall width, 55½ in (141 cm.). Height to scuttle, 23 in (58·4 cm.); overall height, 29 in (73·7 cm.). Ground clearance, 12·7 cm. (5 in). Weight, less fuel, 750 lb (342 kg.).

Research and Development

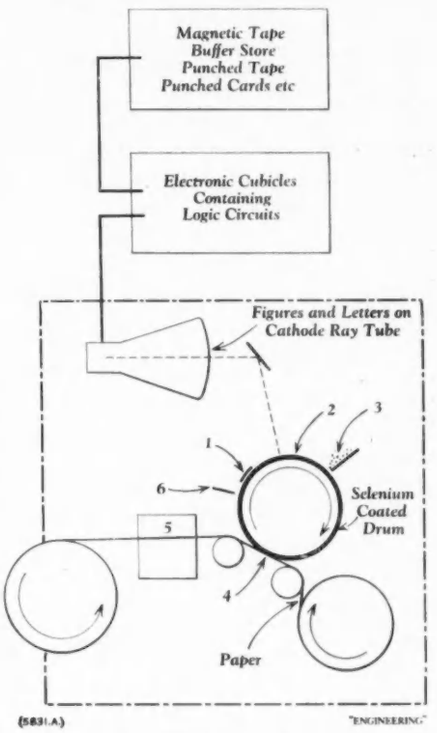
FROM CODED TAPE TO PRINT

Xerographic Printing

A printer that provides for a high outflow of data from a computing system was shown at the recent Electronic Computer Exhibition by Rank Precision Industries Limited, 37 Mortimer Street, London, W1. The machine makes use of the xerographic process and prints at 1,500 lines per minute, the standard line having 128 characters. The machine shown was, however, a prototype and the final model will give speeds up to 3,000 lines per minute with 256 characters per line. Lines are spaced at six to the inch.

The characters are printed on to plain paper or pre-printed stationery. No specially prepared or pre-sensitised papers are used. A feature of the printer is that it is easy to change the type face of the characters or to add new ones to the repertoire. The standard repertoire is 54, but up to 128 characters can be provided. Since the logic of the machine includes both horizontal and vertical tabulation facilities, it is possible by coding " orders " into the input information to arrange the layout of data as required. Use of interchangeable plug-boards allows a new set of orders to be given, changing the layout to fit the particular form in use. It is, in fact, possible to print forms and data at the same time, using plain paper feed. When required, a system for recording the output data on microfilm at the same time as it is printed on paper can be incorporated. The microfilm will act as a file copy if required.

Input to the " Xeronic " may be either from magnetic tape or directly from the computer buffer store. In certain cases the data may be accepted from punched cards or punched paper tape. The coded input signals are converted by logical circuits having transistorised control into wave forms, which when fed into a normal cathode ray tube generate figures and letters on the screen. These characters are then printed on to a continuous roll of paper, using a Rank-Xerox " Copyflo " automatic printer. The accompanying illustration shows such a printer fitted with a cathode-ray tube head. The logical circuits are housed in other cabinets not shown in the installation.



The heart of the xerographic machine is a drum coated with selenium. The cycle of operation is described in the text.

The mode of operation of the Copyflo printer is indicated in the drawing. At (1) the surface of a selenium coated drum receives an electrostatic charge by passing under a wire grid. Selenium has the property of retaining the charge as long as no light shines on it. As the drum continues to revolve, images of letters and figures from the cathode-ray tube fall on to its surface at (2). Where the light falls the charge is dissipated; where no light falls the charge remains. When the pattern of charge reaches (3), special powder is dusted on to the drum and only adheres to the discharged areas, revealing the image in powder form. At (4) the roll of paper comes in contact with the drum, moving at the same speed: powder is transferred from drum to paper by applying a further charge. The heater (5) fuses the powder and bonds it with the paper, making it permanent. At (6) the drum is dusted off to make it ready for re-use.

THIS IS A SAMPLE OF PRINTING FROM THE
'CREED' MODEL 1000 MOSAIC PRINTER.
(EXPERIMENTAL MODEL) AT THE RATE OF
100 CHARACTERS A SECOND.

THIS SPECIMEN HAS BEEN PRINTED AT 1500 LINES
A MINUTE ON THE PROTOTYPE XERONIC HIGH SPEED
COMPUTER PRINTER AT A RATE OF 5000
CHARACTERS A SECOND.

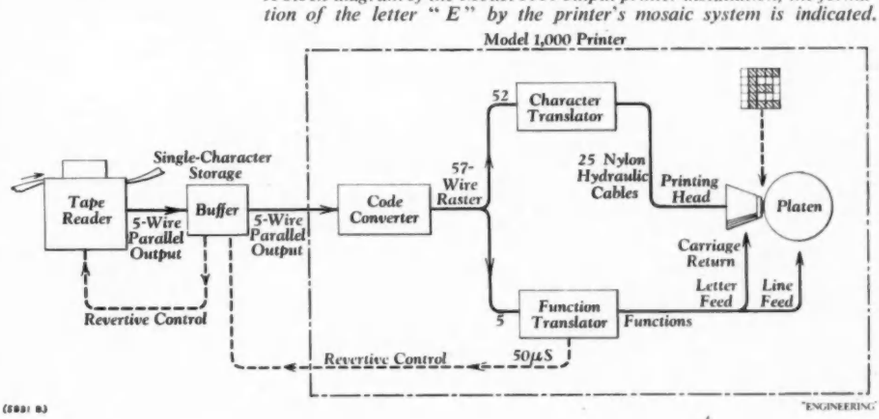
Electro-Hydraulic Printing

An output printer, Model 1000, working at 100 characters per second was demonstrated by Creed and Company Limited, Telegraph House, Croydon. It prints character by character. The print head consists of 25 styli that are bunched together in a rectangular array about 0·1 in high and 0·08 in wide. By arranging different combinations of styli to strike a carbon tape, different letters and figures are formed. The method of building up individual letters piece by piece has been called mosaic printing: it permits a gain in speed of about 15 : 1 over printing by solid type heads. The styli are activated hydraulically by oil at 350 lb per sq. in.

The printer contains a code converter unit, character and function translator units, and printing and platen units. The machine is intended for five-channel tape and accepts a five-wire input. When connected to a tape reader the installation incorporates a buffer stage with single character storage, as indicated in the accompanying block diagram. The sequence of operations is as follows.

When the power to the printer is switched on, a pair of contacts in the function translator starts to transmit control signals to the buffer every 10 milliseconds. The pulses representing the first character from the reader enter along the five wires to the buffer, where they are stored by cold cathode tubes. The next control signal from the printer causes the buffer to retransmit the combination to the code converter and at the same time to send a signal to the tape reader " asking " for another character. The code converter changes the combination of pulses at its five-wire input into the energisation of one of its 57 output wires, 52 of which go to the character printer. The other five go to the function translator. The energising of one of the 52 output wires of the character translator results in the opening of valves to a selection of the 25 nylon hydraulic cables that activate the styli. The output from the function translator provides such functions as " carriage return " or " vertical tabulation."

A block diagram of the Model 1000 output printer installation; the formation of the letter " E " by the printer's mosaic system is indicated.



Production

WORK MEASUREMENT *and* PRODUCTIVITY COMPARISON *in Heavy Arc Welded Construction*

By A. G. THOMPSON
B.SC., A.M.I.C.E., A.M.I.W*

HEAVY arc welded construction is a generic term used to cover such diverse products as pressure vessels, ships, tanks, machine components, welded portal frames and plate girders; in fact, any steel structure composed of plates and rolled steel sections and bars welded together. The techniques of work measurement based on time study and of productivity measurement and comparison have not been so widely applied to this type of production compared with, for example, metal machining. Most of the reasons given by management for their reluctance to use these techniques spring from an intuitive recognition of the difficulties of applying them to the heavy fabrication industries.

The main manufacturing stages involved in arc welded fabrication are handling of material into and through the shops, lofting, templating, marking, plate and bar cutting and bending, etc., assembly, tacking, welding, inspection and testing. Many of the processes and operations involved in these various manufacturing stages have the following characteristics:

(1) The number of nominally similar items undergoing an operation is usually very small; frequently it is no more than one or two.

(2) It is often impossible to standardise the important variables which directly affect the work content of a job. Much of the work in these industries is concentrated on the edges of bars and plates and on the joints between these parts. The work content depends at each stage on dimensional accuracy and an error in dimensional accuracy at one stage will often increase the work content at the next stage.

(3) In some of the operations, the operator can alter the work content of the job and this is particularly true of manual arc welding, which is affected by a large number of variables, many of which cannot be standardised or easily controlled.

Nevertheless, there is a need in these industries to be able to estimate or forecast the time to do certain operations or to fabricate complete welded constructions for purposes of tender estimating, shop loading or progressing, cost control and incentive schemes. For most of these purposes, what needs to be estimated is the total time of men or machines to be paid for, that is, the clock hours, and it is only when an attempt is made to separate what might be loosely termed the net productive time from the total clock time that time studies become necessary.

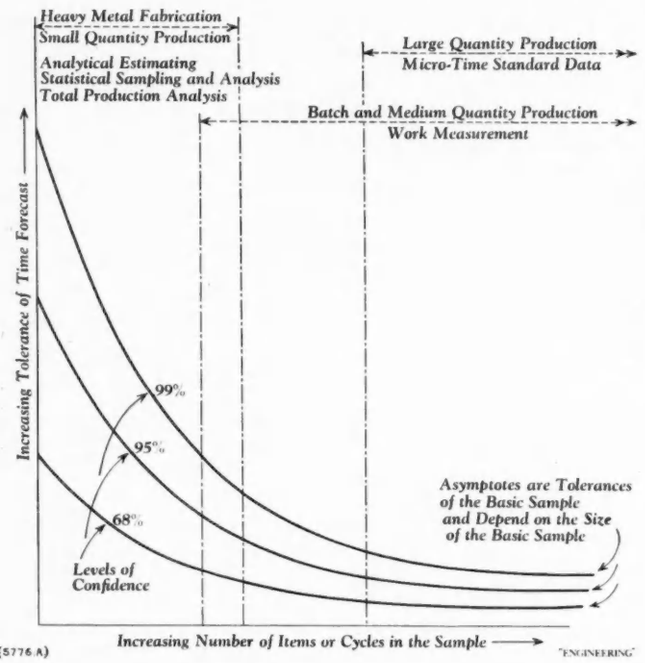


Fig. 1 Effect of the number of items or similar cycles in the sample on the tolerance and confidence of a time forecast.

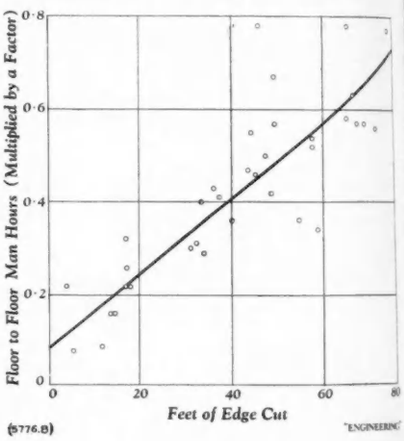


Fig. 2 Plot of time studies for edge planing machine.

The term work measurement is used here to indicate a technique involving time study of operations, while the term productivity measurement refers to the measurement of clock hours to complete a job. Both work measurement and productivity measurement depend on relating inputs, measured as labour times or machine times, with outputs. Generally, the input and the corresponding output are measured and a relation between them is established. This relation is then used to estimate input from knowledge of output as in a piecework scheme, where time is the input value estimated from knowledge of work done. If the relation between input and output is graphed and can be expressed as a straight line through the origin then it can also be expressed as the productivity ratio of $\frac{\text{output}}{\text{input}}$. The productivity so defined can be compared between firms or works or between different periods of time for the same works.

PROBLEMS OF WORK MEASUREMENT

In work measurement, the object is to determine the time to complete a cycle of operations which constitutes a recognisable job, such as welding a seam or shearing a plate. The only way this can usually be done with any hope of obtaining an accurate result is by measuring both the time and the output for the job, so establishing the relationship that so much output is equal to so much labour or machine time. If a job is one that is repeated exactly in every respect, then one or two measurements of time for the job are all that is necessary. Unfortunately exact repetition hardly ever occurs, for a variety of reasons. If the job is not completely mechanised, the problem arises of the different rates and effectiveness of working of the operator or worker. It has become standard practice to overcome this, for many years, by assessing the rate of working during the test timing; and subsequently, by simple arithmetic, converting all measured times to a standard rating.

Next, the amount of work involved in the jobs can vary, although the jobs may have exactly the same name, description and specification. For example, " identical " butt joints may require widely different volumes of weld metal to fill them due to differences in joint fit, that is, the gap between adjoining plate edges. A similar effect occurs when the tools themselves vary in performance in a random way. For example, arc welding currents may vary due to changing loads on a works power supply system. Finally, the operator or worker may himself be able to control the amount of work involved in doing a particular job, in a way that is difficult to measure. For example, small fillet welds with leg lengths varying from $\frac{3}{16}$ in to $\frac{5}{16}$ in are widely used. It is possible for the operator making this type of weld to vary the size of the weld in a way that is

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difficult to measure but which can have an appreciable effect on the time to deposit a given length of weld.

Even if the effect of labour rate of working and effectiveness can be eliminated (which is doubtful), variation in times between nominally identical jobs still occur, simply because in actual fact they are not identical. The amount of variation may be small or may exceed 100 per cent.

The best that can be done in establishing a basis for forecasting, with so much variation occurring, is to obtain the average of as many values of time per item (or foot or ton, etc.), as possible. Furthermore, when it comes to forecasting, the forecast will be generally safer and more accurate, if the number of items being considered, in other words the batch size, is large.

The variation about the average or mean enables both the reliabilities of the average and the accuracy of future forecasts to be estimated. These may be expressed by the terms *tolerance* and *confidence* which are inter-related (Fig. 1). The confidence is a measure of the likelihood of finding a random value within a range of values defined by the tolerance. The tolerance is generally defined as a plus and minus percentage of the mean of the range. The tolerance and confidence are positively related. For various management purposes involving estimation, it is possible to derive values of the desired tolerance and confidence of an estimating relationship from knowledge of the accuracy required and the risk and cost of making a wrong decision. For comparison purposes, the tolerance and confidence are fundamental in demonstrating whether a difference between two series of values is significant or accidental. To give an example, the chance of the time to do a certain operation being less than 1·5 min or greater than 1·7 min is 1 in 20, is a typical statement of accuracy and to illustrate the way the tolerance and confidence change, the chance becomes approximately 1 in 3 for the range 1·55-1·65 min and about 1 in 100 for the range 1·45-1·75 min.

This variability, then, brings the work measurement into the field of chance and risk, not unfamiliar to either management or labour in industry. Every estimate or forecast has the risk of an error. The risk of relatively small errors is very much larger than that of relatively large errors. Both the risk and the errors may be very much reduced by increasing the number of values from which the basic average values are calculated and subsequently in forecasting, by dealing with batches as large as possible. The effect of batch size on confidence and tolerance may be seen in Fig. 1.

These problems are highlighted in the welded fabrication industries where there is very little repetition of jobs and where, in addition, the nature of the work involves variations of 100 per cent in the so called work-content of nominally identical jobs. In this field, industry takes a tremendous number of risks without very often asking about the odds.

TWO APPROACHES TO WORK MEASUREMENT

In order to overcome the difficulties described, two approaches are possible. The first to be described is the familiar standard work measurement approach, whilst the second is that considered more appropriate for the highly variable production under consideration. Before outlining these, it is useful to recollect that the reason why variations occur is because a large number of technical factors, and some human ones as well, vary from "identical" jobs to "identical" jobs both in themselves and in the way they combine. The standard work measurement approach standardises all conditions before making any time studies. The second approach randomises all conditions during time studies, i.e. allows all the variations that normally occur in production to occur during the time studies.

The standard work measurement has some advantages. If all the conditions are standardised, the time measured under these conditions has an absolute value and a time so measured in one place can be transferred and used somewhere else. If it can be demonstrated that most operations are made up of repeated elements of work, then the idea develops of dividing all work into elements of work, the times for which are measured under completely defined and standardised conditions.

The advantage from the point of view of the cost of making measurements is the ability to create a library of elements which can be combined in an infinite number of ways. Hence the times for new jobs and improved old ones may be synthesised, provided of course, that there is complete, or almost complete, standardisation of the job both during time study and subsequent production.

The alternative, on the other hand, is to recognise that the time measured is only relevant for the place where it has been measured, and does not apply anywhere else.

The advantages of element time study are great until variability and non-standardisation appear. In the heavy fabrication industries these factors assume significant importance. No longer is it possible to standardise the job any more than it is possible to standardise a racehorse. Consequently, no longer is it possible to transfer a time measured at one place to somewhere else. Because things must be taken "as they are," in some respects, they might as well be taken "as they are," in all respects, except perhaps where the effect of some factor is amenable to a simple and accurate theoretical calculation.

TWO WAYS OF OBTAINING ACCURACY

The breaking down of the work into elements may also be considered to represent one of two possible methods of obtaining improved accuracy. Increased accuracy is believed to be obtained if, instead of timing the complete job, the separate elements making up the job are timed (and corrected to a standard labour rate of working), and then added together again. This is not necessarily a scientific fact and some evidence points in the opposite direction. The advantage of using elements is the ability to build new jobs with them from old ones. Where this possibility is absent, due to the inability to standardise, much of the advantage of breaking the job up into elements is lost. It probably does not do much harm, but, equally it also probably does very little good.

The alternative approach to obtaining accuracy in time study is not to break the job down, but to relate the time to do the job with the values of those factors, in or about the job, which most affect this time. First of all, the time may be related to the most obvious feature of the job, for example, its weight or surface area, or length, etc.

To give an example, a common operation in tank work is to plane some or all of the edges of a rectangular plate, using a plate edge planing machine. The element time study approach to this job is well-known, consisting of dividing the job up into work elements such as, "attach crane slings to plate," "lift plate on to table of machine," "adjust edge of plate in machine," etc. These elements are timed, rated, corrected to standard rating, etc. One element in particular cannot be standardised and this is the machining element, because the amount of material to be removed from the edge of the plates varies from plate to plate and, in fact, from edge to edge. Further, some of the other elements will depend on the weights of different plates and the bulkiness, that is, the surface area.

The alternative approach is to measure for a series of test plates, the total floor-to-floor time (corrected to standard rating if required and with any idle or ineffective time subtracted), and the length of edge prepared. These values are then plotted on a graph as in Fig. 2, and a mean line drawn through the points.

This mean line enables the time to prepare a plate to be obtained, if the length of edge to be prepared is known. The points shown in Fig. 2, are practical ones, including some plates that have only had one side machined and others

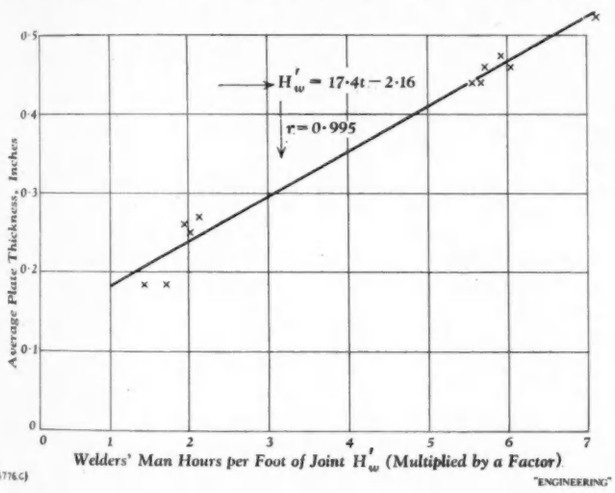


Fig. 3 Total welder's manhours for fabrications related to the total joint length and average plate thickness.

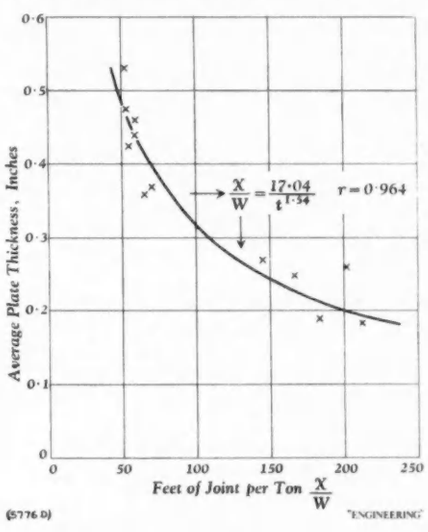


Fig. 4 Relation between measures of output-weight of fabrication, average plate thickness and feet of joint.

Continuing **Production**

with all sides machined. Each extra side to be machined involves unclamping the plate, swinging it round, resetting and reclamping it again. The points on the graph include thick plates and thin ones, long and short ones, plates having had an inch or so machined off an edge and others from which barely a shaving has been removed. It is therefore surprising to discover that the maximum error in estimating the total floor-to-floor time worked by one man for a week does not exceed about 8 per cent too high or too low, in 19 weeks out of 20. This is the maximum error expected in any one week between, for example, the time worked and the time paid for. For most weeks, the error will be a little more than the time paid for and other weeks a little less.

Why does such a simple basis provide a useful method of time forecasting? Part of the answer lies in the fact that when the floor-to-floor time is related to feet of edge cut, it is also related with the weight of plates, in so far as the weight of plate increases broadly with feet of edge cut, and also with plate area and the number of edges cut for the same reason. Part of the answer also lies in plotting the points on a graph, thus linking a whole series of what would otherwise have been many separate groups of points, defined, perhaps, by plate size and plate weight. Yet another explanation lies in allowing all the variations that are subsequently going to occur in production, to occur also during the time studies. For example, the variations of plate size and thickness that occur in the tests will subsequently occur in production.

Further improvement in accuracy can be obtained by making more tests, but this is a procedure of diminishing returns and after about 100 tests it becomes less worth while. If further accuracy is required, some grouping of the work may be desirable. It may, in fact, be worth while to draw two lines; for example, one for plates having only one or two edges prepared and another for plates having three or four edges prepared. Alternatively, greater accuracy may be obtained by introducing another variable. For example, plate thickness might be important and to test whether this is so, the time per foot of edge cut for each plate, might be plotted against the plate thickness for each plate.

This description shows the principle of what might be called an operational research approach. The end result is a simple graph or table where the time required is given in terms of one or two quantities that can be measured from a drawing. Consequently, the graph or table can be used before the work is done and no measurements on the job are necessary.

The mean line on which everything depends can be " drawn in " mathematically by regression analysis involving a series of computations which can be carried out with a standard desk type computer. The line can almost equally well be drawn in by eye but calculation yields not only the best line, but also information about the accuracy of the line and forecasts based on the line.

PROBLEM OF PRODUCTIVITY MEASUREMENT

Productivity measurement at what might be called the shop floor level can be tackled in a similar manner to that described immediately above for work measurement. The net productive times for a series of operations are now replaced by the clock man hours for various trades to complete, in the present context, welded fabrications. The output is again measured in terms of physical properties of the welded fabrication such as its weight, the length of joint involved in its construction, the average thickness of the plates composing it and so on.

An example of this method is illustrated in Fig. 3. Each point of the graph relates to a welded tank structure, the ordinate being the average plate thickness and the abscissae being the total welders' man hours divided by the feet of joint in the particular fabrication. The points on the graph represent a wide range of sizes of tank, varying from 0·3 ton to 35 tons. A straight line may be drawn through the points and if this is done the relationship is,

Welders' man hours per foot of joint =
17·4 × the average plate thickness − 2·16.

Alternatively, a curve may be put through the points giving a relationship as follows:

Man hours per foot of joint = 24·2 (average plate thickness)² − 1·08.

Relationships such as these provide a basis for estimating labour man hours to complete a job from knowledge of the physical properties of the fabrication, such as, in these examples, the joint length and average plate thickness. The principle which has been demonstrated here can be extended to many types of products, for many purposes.

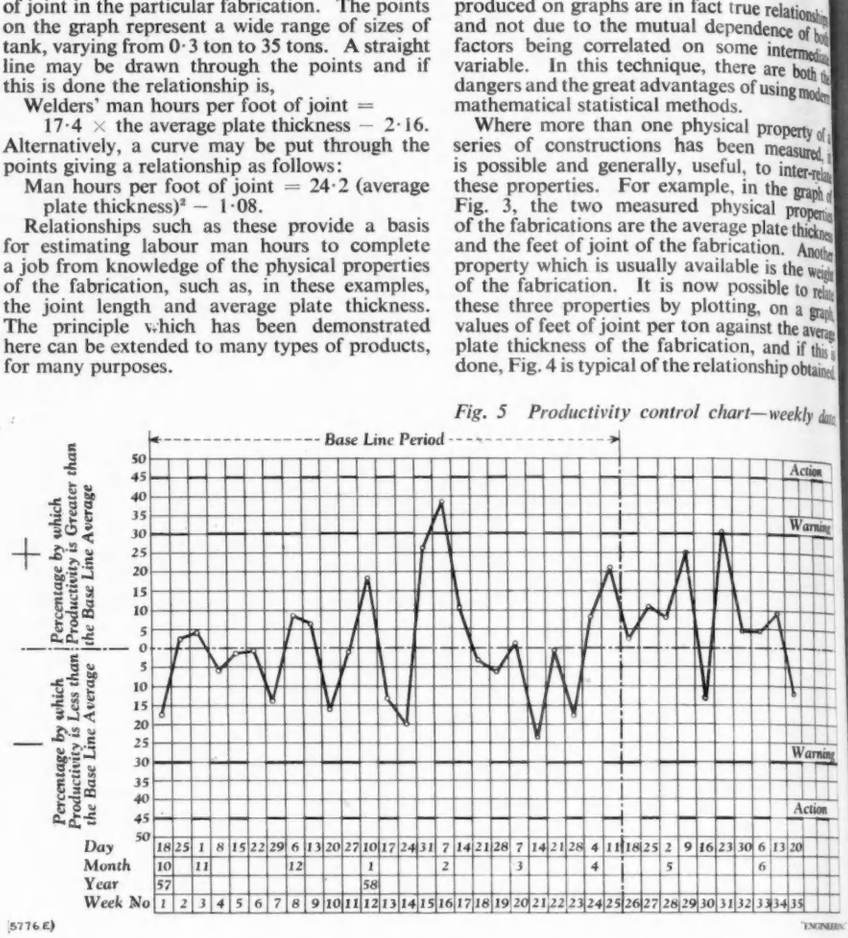
To generalise, the basic principle of the technique is to relate the input factors that are of interest, e.g. labour man hours in trades or machine hours, etc., with the measure of output, on which it appears most obviously that the man hours will depend. In steel fabrication work this measure of output is usually taken as tons weight. In other industries and trades there are similar " obvious " measures of output. The inputs and outputs are then plotted as described above and the amount of scatter of the points about the average line is analysed. This can be done mathematically, or alternatively, it can be done approximately by drawing in the top and bottom lines which envelop the points, and measuring the divergences of the envelope lines from the average line. The amount of scatter about the average line is also a measure of the lack of accuracy of the average line itself; and also of the lack of accuracy of future estimates based on the average line.

The amount of accuracy required in estimating clearly depends on the purpose for which the estimate is required. All that has been said in connection with the alternative approach to work measurement also applies to the productivity measurement technique, because both techniques are based on the same principle. The error of an estimate for one item based on the line of Fig. 3 will be about ± 12 per cent. If the batch size to be estimated increases from 1 item to 12 items, then the error of the estimate for the total of the 12 items will be reduced to ± 5 per cent. These limits of error are such that they will not be exceeded on average by more than 1 estimate in 20 (i.e., 5 per cent of estimates).

Fundamentally, the technique is simple, although in practice care has to be exercised to ensure that relationships which are being produced on graphs are in fact true relationships and not due to the mutual dependence of both factors being correlated on some intermediate variable. In this technique, there are both the dangers and the great advantages of using modern mathematical statistical methods.

Where more than one physical property of a series of constructions has been measured, it is possible and generally, useful, to inter-relate these properties. For example, in the graph of Fig. 3, the two measured physical properties of the fabrications are the average plate thickness and the feet of joint of the fabrication. Another property which is usually available is the weight of the fabrication. It is now possible to relate these three properties by plotting, on a graph, values of feet of joint per ton against the average plate thickness of the fabrication, and if this is done, Fig. 4 is typical of the relationship obtained.

Fig. 5 Productivity control chart—weekly data



(5776.E)

If the length of joint in a fabrication for a given average plate thickness has been shown to be correlated with, and to be a measure of, the labour welding cost, it is evident that the graph of Fig. 4 can provide a basis for measuring or assessing the " design-for-production " efficiency. A design which gives a point above the line of Fig. 4 is less efficient from the design-for-production point of view than the group of fabrications which have already been considered and which are represented by the full line. A design which gives a point below the line of Fig. 4 is more efficient than the average. Fig. 4 enables material cost to be related to the labour production cost relationship of Fig. 3.

This consideration of production and material costs in design is a fruitful field for development and research, in order to produce fabrications having the minimum total cost and maximum profitability.

Relating the input and output as described above for separate fabrications may be dealt with in other ways. For example, the input and output of a workshop for a series of weeks may be related on a graph. The total of man hours expended in the shop for each week is measured and the output of the shop is also measured in some way. Measurement of output per week is generally arduous but, where piecework systems are already in operation, it is often possible to use one of the piecework measures as a measure of output. If this is done, a graph of input against output is obtained and the average line can be drawn through the points each of which represent one week's production. This may be done for a base period of some 30 or 40 weeks and if the measure of output has been carefully chosen, the mean line through the weekly points will have reasonable accuracy. For each subsequent week beyond the base period, the difference

between the actual man hours expended during that week may be compared with the "base line" man hours, which is appropriate to the output for that week. These "base line" man hours would be estimated from the average line for the base period. The difference between the actual man hours and the estimated base line man hours may be obtained and expressed as a percentage of the estimated man hours. This percentage may be positive or negative depending on whether the actual man hours exceed or fall short of the estimated man hours. The plus or minus percentages so obtained for a series of weeks can be plotted out on a graph in the same way as values are plotted on a control chart in quality control techniques and an example is illustrated in Fig. 5. The same sort of statistical technique can be used to derive action and warning limits and this provides a useful method of controlling productivity and costs for manufacturing shops, trades, etc. The difference between estimated and actual man hours may also be considered as hours saved, and these may be used to provide a basis for a bonus incentive scheme for shops or trades within a shop.

SUMMARY

Statistical sampling and analysis (SSA) is an alternative method of work measurement for use where there is lack of repetition of elements and where it is difficult or impossible to standardise all the conditions affecting the measured times. The essentials of SSA are the use of the "floor-to-floor" time or its equivalent for complete jobs, the correlation of these times with the most important variables affecting them and the randomisation of all other variables.

Total production analysis is a technique of relating the man or machine hours to complete a job with the most important variables affecting those times. This method enables estimating, group bonus schemes, shop loading and productivity comparisons to be performed from sample shop records and is particularly applicable in those industries where the trade unions concerned will not allow time studies to be made. It is also possible to establish criteria of good or poor design from a production cost viewpoint.

ACKNOWLEDGEMENTS

The writer gratefully acknowledges the dependance of some of the ideas put forward in this article on the following previously published material.

P. Lyle, *Regression analysis of production costs and factory operations*. 2nd Edition. Oliver and Boyd, 1946.

A. Abruzzi, *Work measurement—new principles and procedures*. Columbia University Press, 1952.

Norman R. Neal, "The application of statistical methods to the control of industrial costs." *Proceedings of the Institution of Mechanical Engineers*. Vol. 152, 1945, p. 76.

THE BEGINNINGS OF THE STEEL AGE

Commemorating Abraham Darby's Work in 1709

It is not, as a rule, easy to divide a particular branch of industrial history into clearly-defined periods, each of which is marked by some outstanding technical development. More often than not, only the cumulative effects of many small events can be seen. But there are exceptions to this fairly general rule, and the iron and steel industry provides what is perhaps the best example of all. The long history of iron and steel can be divided into several distinct periods, each of which was heralded by a single technical development. One of these epoch-making changes, the introduction of coke in place of charcoal for smelting iron ores, took place 250 years ago.

From the earliest days until about the 15th century, iron was made by a direct process, straight from the ore. Outputs were small, the process was inefficient, and expansion on a large scale was impossible. Then a technical change, the introduction of the blast furnace (which reached this country from the Continent, c. 1490/1500), enabled iron to be made on a larger scale. Next, in 1709, came the great development due to Abraham Darby I in Shropshire, of using coke in the blast furnace. This freed the ironmasters from their dependence upon the rapidly dwindling supplies of charcoal and made possible an enormous expansion of production in more convenient localities. The need for a means of using mineral fuel instead of charcoal had existed for a long time, and numerous attempts had been made to solve the problem.

As is frequently the habit with patentees, more success had been claimed than was justified, and it is now known that Darby was the first to succeed.

This new technique, coupled with the development of a reliable form of steam engine, which followed it some 60 years later, and with further advances in iron-making methods based on the use of mineral fuel, set the stage for the great expansion of the iron industry which was to take place in the 19th century. Coke-fired blast furnaces are now—and are likely to remain—responsible for the major part of the world's output of iron.

Mild steel began to supersede wrought iron from about 1860 onwards, slowly at first but with ever increasing speed, until now the older wrought iron has given way entirely to steel in its many modern forms. But steel originates in the blast furnace which, altered in size and shape mechanised in operation, and of vastly increased output, is still nevertheless fundamentally of the type first set to work successfully by Abraham Darby 250 years ago.

Darby's work provides one of those rare examples of a single development which marked the beginning of an industrial era, and a committee has been set up to see that the event is suitably commemorated. Under the chairmanship of Sir Frederick Scopes, of the Joint Iron Council, the committee is widely representative of industrial, professional, academic and historical interests, and is receiving the fullest support from Allied Ironfounders Limited, whose subsidiary, the Coalbrookdale Company, occupies the original Darby works site.

Papers by distinguished industrial historians, a celebration dinner and a visit to the furnace site, are the principal items on the programme. The Coalbrookdale Company has itself undertaken to preserve as a permanent memorial the remains of a blast furnace of 1638 enlarged in 1777 by Abraham Darby III, to make the iron for the world's first iron bridge, erected over the River Severn not far from the works in 1779.

Detailed arrangements will be announced by the committee, the secretary of which is Mr. K. Headlam-Morley, the Iron and Steel Institute, 4 Grosvenor Gardens, London, SW1.

Destruction in Production

US Air Force Atlas intercontinental ballistic missiles are assembled and checked out in the San Diego, California, plant of Convair (Astronautics) Division of General Dynamics Corporation. Shown in this first photo of the production line are vehicles to be fired in the test programme, and similar missiles intended for operational squadrons. The big stainless steel missiles—10 ft in diameter and 75 ft long—are nested in elevated docks. The area underneath is filled with equipment bins and the electronic equipment required for checkout of the missile subsystems. At the upper left, the booster sections of the missile have been pulled back to permit simultaneous installation of the two booster engines and the sustainer engine of the Atlas. Test missiles are delivered from the factory to static test facilities at Sycamore Canyon and the Missile Static Test Site at Edwards Air Force Base in California and the launching complexes at the Atlantic Missile Range, Cape Canaveral, Florida. The first operational missiles will be delivered to Vandenberg Air Force Base, California.

SPEEDING MALLEABLE CASTINGS

Electric furnace equipment for annealing pearlitic malleable iron castings and having an output of 1 ton per hour is to be installed in the new mechanised foundry of Ley's Malleable Casting Company Limited at Derby. The contract for the equipment has been placed with Birlec Limited, Erdington, Birmingham, 24.

The equipment will comprise three main parts: a high temperature furnace, a fast cooling conveyor and a low temperature furnace. Both furnaces will employ pusher mechanisms to move trays of castings from end to end. Transfer of castings from the high temperature trays to the cooling conveyor and thence to the low temperature trays will be fully automatic. Thus, no manual handling operations will be required between the charge and discharge ends of the line. The trays will be of the open type, and scaling of the castings during treatment will be avoided by the use of a controlled atmosphere.

MEETINGS AND PAPERS

Association of Supervising Electrical Engineers

LONDON
"Hospital Electrical Installations and Apparatus," by J. W. J. Leslie. Institution of Electrical Engineers, Savoy Place, Victoria Embankment, WC2. Tues., 24 Feb., 6.30 p.m.*

British Institution of Radio Engineers

LONDON
"Patents and the Radio Engineer," by E. D. Swann. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 25 Feb., 6.30 p.m.

CHELTENHAM
"Micro-miniaturisation," by G. W. A. Dummer. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., 27 Feb., 7 p.m.

Chemical Society

LONDON
"The Origin of the Elements," by Professor F. Hoyle. Royal Institution, Albemarle Street, W1. Thurs., 26 Feb., 7.30 p.m.

ST. ANDREWS
"Molecular Shapes and Sizes," by Dr. L. E. Sutton. St. Andrews and Dundee Branch. Chemistry Department, St. Salvator's College, St. Andrews. Fri., 27 Feb., 5.15 p.m.

Combustion Engineering Association

PORT TALBOT
"Reactor Engineering," by J. W. Ashley at 11 a.m.*; "Refining of Crude Oil and the Use of the Products," by R. R. B. Cox, at 2.15 p.m. Western Region. Old Head Office of the Steel Co. of Wales Ltd., Port Talbot (adjacent to Port Talbot Station). Wed., 25 Feb.

Illuminating Engineering Society

BIRMINGHAM
Annual General Meeting and an address by the president. Birmingham Centre. Regent House, St. Phillips Place, Colmore Row, Birmingham. Fri., 27 Feb., 6 p.m.

Institute of Fuel

LONDON
"Problems of Air Pollution in Germany," by Dr.-Ing. Heinrich Lent. Institution of Civil Engineers, Great George Street, SW1. Wed., 25 Feb., 5.30 p.m.*

Institute of Marine Engineers

BOLTON
"Steam Reciprocating Engines," by G. Yellowley. Merseyside and North Western Section. Bolton Technical College, Bolton. Tues., 24 Feb., 3.15 p.m.

BRISTOL
Films: "How a Reactor Works" and "Construction of Calder Hall." Followed by the Annual General Meeting. West of England Section. Grand Hotel, Bristol. Mon., 23 Feb., 7.30 p.m.

NEWCASTLE UPON TYNE
"Auxiliaries," by P. Scorer. North East Coast Section. Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne. Thurs., 26 Feb., 4 p.m.

Institute of Marine Engineers and Institution of Naval Architects

LONDON
"Fishing Vessel Development," by A. Hunter and G. C. Eddie. 76 Mark Lane, EC3. Tues., 24 Feb., 5.30 p.m.*

Institute of Metals

SHEFFIELD
Symposium on Corrosion Problems. Sheffield Local Section. The University, St. George's Square, Sheffield. Thurs., 26 Feb., 2 p.m.

Institute of Petroleum

LONDON
Address by the president, C. M. Vignoles. London Branch. Wed., 25 Feb., 6 p.m.*

Institution of Chemical Engineers

CHESTER
"Meat Extract Production in a Whaling Factory Ship," by D. King. North Western Branch. Blossoms Hotel, Chester. Tues., 24 Feb., 7 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of the Avon Dam," by J. M. Linton Bogle, R. M. Ross and Thomas McMillan. Tues., 24 Feb., 5.30 p.m.*

LIVERPOOL
"Organisational Problems Associated with the Construction of Large Nuclear Power Stations," by J. H. W. Turner. Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool. Wed., 25 Feb., 6.30 p.m.

Institution of Electrical Engineers

LONDON
Various short papers. Radio and Telecommunication Section. Mon., 23 Feb., 5.30 p.m.*
"Development of High-Voltage Air-Break Circuit-Breakers with Insulated-Steel-Plate Arc Chutes," by F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton. Supply Section. Wed., 25 Feb., 5.30 p.m.*

HULL
"Recent Developments in Medium-Voltage High-Breaking-Capacity Fuse Links," by R. H. Dean. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., 26 Feb., 6.30 p.m.

LIVERPOOL
Faraday Lecture on "Automation." Mersey and North Wales Centre. Philharmonic Hall, Liverpool. Thurs., 26 Feb., 6.45 p.m.

MANCHESTER
Faraday Lecture on "Automation." North Western Centre. Free Trade Hall, Manchester. Tues., 24 Feb., 7.30 p.m.

NEWCASTLE UPON TYNE
"Development of High-Voltage Air-Break Circuit-Breakers with Insulated-Steel-Plate Arc Chutes," by F. S. Fay, J. A. Thomas, D. Legg and J. S. Morton. North Eastern Centre. Neville Hall, Westgate Road, Newcastle upon Tyne. Mon., 23 Feb., 6.15 p.m.

WEYMOUTH
"Survey of Recent Developments in Marine Radar," by A. L. P. Milwright. Southern Centre. South Dorset Technical College, Weymouth. Fri., 27 Feb., 6.30 p.m.*

Institution of Electronics

MANCHESTER
"Electronics in Industry: Including Computer Applications," by R. S. Evans. Northern Division. Manchester College of Science and Technology, Manchester. Fri., 27 Feb., 7 p.m.

Institution of Engineering Designers

BRADFORD
"An Outline of Heating and Ventilating Design," by C. F. Hart. Yorkshire Branch. Midland Hotel, Bradford. Wed., 25 Feb., 7.30 p.m.

Institution of Engineering Inspection

MANCHESTER
Discussion on "The Manufacture and Testing of Springs." North Western Branch. Engineers' Club, Albert Square, Manchester. Thurs., 26 Feb., 7.30 p.m.

Institution of Engineers-in-Charge

LONDON
"Factory and Workshop Lighting," by J. F. Roper. British Lighting Council, Brettenham House, Lancaster Place, Strand, WC2. Wed., 25 Feb., 6.30 p.m.*

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"The Stork Marine Diesel Engine: Construction, Experience, Development," by Ir. A. Hootsen and E. A. van der Molen. Tues., 24 Feb., 6.30 p.m.*

Institution of Heating and Ventilating Engineers

GLASGOW
"Air Conditioning—Some Industrial Applications," by H. Poole. Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C2. Tues., 24 Feb., 7 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "Safety Features in Vehicle Design." Automobile Division. Tues., 24 Feb., 6 p.m.*
Discussion on "The Significance of Thermal Stresses in Design." Applied Mechanics Group. Wed., 25 Feb., 6 p.m.*
Discussion on "Choice of Gas Temperature and Steam and Pressure Conditions in Nuclear Power Stations." Arranged by the Nuclear Energy Panel. Fri., 27 Feb., 6 p.m.*

BELFAST
"Some Experiments with Internal-Combustion Engines," by R. O. Cross. Northern Ireland Branch. Belfast College of Technology, Belfast. Wed., 25 Feb., 7.30 p.m.

CHESTERFIELD
"Development and Research in Industry," by H. G. Edmunds. East Midlands Branch. College of Technology, Chesterfield. Wed., 25 Feb., 7.30 p.m.

SHEFFIELD
"Mechanical Marshalling of Railway Wagons in Works Sidings," by G. W. Grossmith. Yorkshire Branch. The University, St. George's Square, Sheffield. Wed., 25 Feb., 6.30 p.m.

Institution of Production Engineers

LINCOLN
"Motor Car Body Industry," by J. H. Stephens. Lincoln Section. Ruston Club, Lincoln. Thurs., 26 Feb., 7.30 p.m.

REDDITCH
"Fibreglass Development and Application," by G. C. Watson. Worcester Section. College of Further Education, Redditch. Thurs., 26 Feb., 7.30 p.m.

SHREWSBURY
"Employers' Liability for Injury at Work," by T. Wylie. Shrewsbury Section. Walker Technical College, Oakengates, Shrewsbury. Tues., 24 Feb., 7.30 p.m.

Institution of Railway Signal Engineers

BRISTOL
Discussion on "Any Signalling Questions?" Temple Meads Station, Bristol. Mon., 23 Feb., 6 p.m.*

Institution of the Rubber Industry

MANCHESTER
"Developments in the Technology of the Direct Moulded Footwear Process," by C. E. Webb. Manchester Section. Grand Hotel, Manchester. Mon., 23 Feb., 6.45 p.m.

Institution of Structural Engineers

LONDON
"Extension to Constructional Shop: 170 ft and Other Long Spans," by F. R. Bullen. Thurs., 26 Feb., 6 p.m.

BIRMINGHAM
"Some Structural Problems Particular to Aircraft Design," by A. J. Troughton. Midland Counties Branch. James Watt Memorial Institute, Great Charles Street, Birmingham. Fri., 27 Feb., 6.30 p.m.

Junior Institution of Engineers

LONDON
"Computers and Materials Handling," by W. J. Kease and A. C. Quarterman. Fri., 27 Feb., 7 p.m.*

Liverpool Engineering Society

LIVERPOOL
"Organisation of Large Nuclear Power Projects," by J. H. W. Turner. Wed., 25 Feb., 6 p.m.

Manchester Association of Engineers

MANCHESTER
"Electrical Models and Analogues," by Professor E. Ha... shaw. Engineers' Club, Albert Square, Manchester. F... 27 Feb., 6.45 p.m.

Manchester Statistical Society

MANCHESTER
"Applications of Linear Programming Techniques to Pro... of Production and Distribution," by Dr. A. Baines, Indus... Group. Portico Library, 57 Moseley Street, Manches... Fri., 27 Feb., 6 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE UPON TYNE
"Some Engineering Developments in the Nuclear Po... Field," by Dr. A. T. Bowden. Mining Institute, Westg... Road, Newcastle upon Tyne. Fri., 27 Feb., 6.15 p.m.*

Reinforced Concrete Association

BRISTOL
"A Survey of Recent Developments in Reinforced Concre... by A. W. Hill. West of England Branch. New School ... Engineering, The University, Bristol. Thurs., 26 Feb., 6 p.m.

Royal Aeronautical Society

LONDON
"The Flight Development of an Aircraft Before and During ... Operation," by Dr. A. E. Russell, C. Abell and Dr. L. ... Warlow-Davies. Tues., 24 Feb., 7 p.m.

Royal Institution

LONDON
Salters' Lecture on "The Significance of Colour in Inorga... Chemistry," by Professor R. S. Nyholm. Afternoon lectu... for sixth formers. Tuesdays and Wednesdays, 24 and 25 Fe... and 3 and 4 March., at 5.30 p.m. in each case.

Royal Society

LONDON
Various short papers. Thurs., 26 Feb., 4.30 p.m.*

Royal Society of Arts

LONDON
"Designing, Building and Sailing Yachts and Boats," b... Uffa Fox. Wed., 25 Feb., 2.30 p.m.

Royal Statistical Society

SHEFFIELD
"Analysis of Replicated Experiments on an Electronic Co... puter," by M. J. R. Healy. Sheffield Industrial Applicatio... Group. Grand Hotel, Sheffield. Thurs., 26 Feb., 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Discussion on a methods of analysis subject. BISRA Labor... tories, Hoyle Street, Sheffield. Tues., 24 Feb., 7 p.m.

Sheffield Society of Engineers and Metallurgists

SHEFFIELD
"The Mechanical Marshalling of Railway Wagons in Work... Sidings," by G. W. Grossmith. Wed., 25 Feb., 6.30 p.m.

Society of Instrument Technology

LONDON
"Automatic Production Line Weighing Techniques," by A. L. Hendon and G. C. Chapman; "Batch Weighing," by R. ... Settle; and "An Electro-Pneumatic Constant-Weight Feed... for Ore Blending," by E. I. Lowe and M. J. Harris. Manso... House, Portland Place, W.1. Tues., 24 Feb., 6 p.m.*

CHESTER
"Automatic Boiler Control," by J. E. O'Breen. Chest... Section. Grosvenor Museum, Grosvenor Street, Chester. Wed., 25 Feb., 7 p.m.

Television Society

LONDON
Film Evening. Cinematograph Exhibitors' Associat... 164 Shaftesbury Avenue, WC2. Fri., 27 Feb., 7 p.m.

Women's Engineering Society

LONDON
Film Evening. London Branch. 45 Great Peter Street, SW... Wed., 25 Feb., 7 p.m.*

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this feature should reach the Editor not later than three weeks before the date of the meeting.

* An asterisk is placed where it is understood that refreshments are available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675.)
Combustion Engineering Association, 6 Duke Street, St. James's, London, SW1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215.)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark Lane, London, EC3. (ROYal 8493.)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291.)
Institute of Petroleum, 61 New Cavendish Street, London, W1. (LANgham 3583.)
Institution of Chemical Engineers, 16 Belgrave Square, London, SW1. (BELgravia 3647.)
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (TEMple Bar 7676.)
Institution of Electronics, 78 Shaw Road, Thornham, Rochdale, Lancs. (Oldham Main 6661.)
Institution of Engineering Designers, 38 Portland Place, London, W1. (LANgham 8847.)
Institution of Engineering Inspection, 28 Victoria Street, London, SW1. (ABBey 3794.)
Institution of Engineers-in-Charge, 13 Grange Close, Edgware, Middlesex. (MILl Hill 3543.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158.)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave Street, London, SW1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254.)
Institution of Railway Signal Engineers. Apply to Mr. R. L. Weedon, 222 Marylebone Road, London, NW1. (AMBassador 7711.)
Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave Street, London, SW1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester Row, London, SW1. (VICtoria 0786.)
Liverpool Engineering Society, 9 The Temple, 24 Dale Street, Liverpool 2. (Central 3717.)
Manchester Association of Engineers, 18 Booth Street, Manchester 2. (Central 1717.)
Manchester Statistical Society. Apply to Mr. T. J. Lunt, Ferranti Ltd., Hollinwood, Lancs.
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, SW1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle Street, London, W1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W1. (REGent 3335.)
Royal Society of Arts, John Adam Street, Adelphi, London, WC2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck Street, London, W1. (WELbeck 7638.)
Sheffield Metallurgical Association, 64 Crescent Road, Sheffield 7. (Sheffield 52865.)
Sheffield Society of Engineers and Metallurgists, University of Sheffield, St. George's Square, Sheffield 1. (Sheffield 24071.)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251.)
Television Society, 166 Shaftesbury Avenue, London, WC2. (TEMple Bar 3330.)
Women's Engineering Society, 25 Fubert's Place, London, W1. (GERrards 5212.)

Metals and Materials

TREATED BOILER WATER

The progressive increase in boiler pressures and temperatures which are characteristic of most new designs of steam raising plant for driving turbines has made the control of water quality of prime importance. The water chemist works in parts per million, but even in these small concentrations he aims at elimination of extrinsic dissolved gases and solids to the lowest practicable level, and at ensuring that the presence of any solute in the feed water is deliberate rather than adventitious.

Two papers were recently presented to the Institution of Chemical Engineers* on the subject of water for high pressure boilers, and except for the introduction, they form the basis of the following report; the organisations represented by the authors were the Central Electricity Generating Board, and Imperial Chemical Industries Limited.

PURIFICATION—WHY

Treatment of boiler feed water is carried out with three aims: first, to prevent corrosion of the feed system and of the boiler itself by pinhole attack, general attack or intergranular (caustic) embrittlement; second, to prevent formation of adherent scale on those parts of the boiler which transfer heat; and third, to reduce or modify the deposition of scale on the turbine blades. The problem is attacked in two ways—by removal of harmful chemicals, and by introduction of modifiers and inhibitors. Most boilers are of steel, and the primary cause of corrosion results from the presence of dissolved oxygen which allows a cathodic reaction with formation of hydroxyl ions to occur.

Deaeration is therefore a first function of water treatment. Mechanical equipment is nowadays guaranteed to allow attainment of oxygen concentration of 0·007 parts per million but to allow for adventitious entry, additions of oxygen-absorbing compounds are made—notably sodium sulphite and in recent years hydrazine.

A degree of anodic inhibition and of cathodic polarisation is effected in alkaline solution, for which sodium hydroxide or sodium carbonate may be added.

Intergranular or caustic embrittlement relies on the presence of three conditions—alkalinity, leaks and areas of stressed metal. With the advent of welded and stress relieved boilers in place of riveted ones, the latter two conditions are eliminated, but for protection it is generally recommended that sodium sulphate should be added to maintain a definite sulphate/alkalinity ratio.

The prevention of scale formation inside boilers is important to maintain heat transfer but more especially to avoid formation of hot spots which lead to oxidation and erosion on the flame side of the wall. Most dangerous are those compounds which are less soluble at higher temperatures, such as calcium carbonate. Demineralisation or deionisation go much of the way towards their removal, but further additions of sodium phosphate are commonly made to precipitate the offending salts as a sludge which may be removed from the boiler by blow-down. The addition of tannins, starch or sodium aluminate, is made with the intention of modifying the physical form of such phosphate precipitates to avoid their being adherent.

The remaining problem is of scale formation on the turbine blades. How may this be reduced? The chief offender is silica which may often be present in boiler water in colloidal form. The content of this compound in steam increases very markedly with increase in boiling temperature, and when carried over in concentrations even of 0·1 ppm it leads to formation of a siliceous scale which reduces turbine efficiency and therefore demands attention. Silica is not removed by many demineralisation or deionisation treatments and care has to be taken with blow-down to maintain the boiler water within specification.

* "Feed Water and Boiler Water Standards in the Central Electricity Generating Board" by R. L. L. Rees and F. J. R. Taylor. "The Treatment of Water for an Industrial High Pressure Boiler Plant" by J. Arthurs, J. A. Robins and T. B. Whitefoot.

INSTALLATIONS

The conditions realised in the more recent design of steam plant for the CEGB have become increasingly severe, typical of which are those met in a 200 MW unit to be installed in 1959 with turbine stop valve conditions of 2,350 lb per sq. in at 1,050° F and reheating to 1,000° F. ICI's experience at Wilton has been on older units working at 950 lb per sq. in and more recently at 1,700 lb per sq. in.

Both organisations are faced with the same considerations, although their relative importance affects the size and type of water treatment which is installed. These factors are the quality of raw water, the quality of feed water required for satisfactory operation, the percentage of make-up water required and the desired blow-down rate. Quality of the feed water is something which may and has been laid down by both CEGB and ICI; the methods of reaching the specification are similar but the size of installation are not. The basic reason is that the CEGB are operating on closed-circuit steam while ICI are supplying process steam to the Wilton plant. The make-ups are therefore different—for CEGB, about 1 per cent, and for ICI, 40 to 65 per cent. Over and above the demand for make-up water, treatment capacity must be installed to repurify boiler water blow-down. A balance exists between the amount of make-up water, the blow-down rate, the steaming rate, the boiler water specification and the feed water specification, the main result being that high make-up and blow-down demands large treatment capacity.

Following pretreatment, the CEGB practice is to pass the water together with recirculated water through a mixed-bed deioniser; oxygen is removed to below 0·007 ppm by standard mechanical deaerators. Special attention has been given to avoiding pick-up of impurities from the feed-water storage tanks for which various materials such as reinforced plastics, aluminium and stainless clad steel are being considered in this country.

For their high pressure boilers, ICI have installed a cation-anion deionisation system preceeded by clarification. The last mentioned section includes provision for alum and acid flocculation, sedimentation and filtration through rapid gravity filters. The deionisation system consists of cation exchange units charged with high capacity sulphonated polystyrene, a degasser, and anion exchange units charged with quaternary strong base anion exchange material.

WATER SPECIFICATIONS

In the original papers are presented the specifications laid down by CEGB and ICI for both feed water and boiler water. The ICI specification changed during the 10 years of operation, but a good idea of their practice is indicated in the table.

It is recognised that sodium sulphite breaks down at high pressures and evidence so far accumulated by the CEGB suggests a correlation between the use of sulphite and corrosion of 70/30 cupronickel feed heater tubes. In their views on the bad effects of sodium sulphite the two organisations are in accord. What, however, is the alternative? The CEGB are prepared to rely on mechanical deaeration with the possible use of hydrazine, but here they sound a word of caution, because excess hydrazine can decompose to yield ammonia, which they deem undesirable.

ICI would use the same material in place of sodium sulphite, and in the short time in which they have been using it in the high pressure boilers, they have encountered no difficulty.

Sodium sulphate is included in the specifications for both CEGB and ICI. However, the latter, following examination of two 950 lb per sq. in boilers which had steamed for two years, found corrosion caused by oxygen. Improved deaeration subsequently allowed the sulphite to be reduced to 15 ppm and sulphate additions were simultaneously reviewed. It was decided that sulphate could be eliminated, if inspection of bolted flanges was made. So far there has been no evidence of caustic cracking, and the sulphate is left out of their specification.

Silica is the chemical which is said to cause most difficulty. The level in the steam at which it does so is above about 0·1 ppm. ICI performed analyses on the steam, and have arrived at the specifications in the table of less than 40 ppm at 950 lb per sq. in and 2 to 3 ppm at 1,700 lb per sq. in. Under high loading, however, with a silica level of 40 p.p.m., heavy deposits of silica were formed on those sections of the turbine operating between 105 lb per sq. in or 20 lb per sq. in which consisted of 84 to 90 per cent silica and 6 to 12 per cent of a mixture of ferric and magnetic oxides of iron. Their present opinion is that even a silica level of 25 ppm at 950 lb per sq. in may be too high.

In the high pressure field they are in accord with the CEGB who based their figures on a combination of their own and Swedish and American observations. A number of detailed reports from the CEGB power stations has shown that the control of silica is exceptionally troublesome in new plants, primarily because it is difficult to keep siliceous dust out of the system during construction and to wash it out afterwards. Against this, in the high pressure ICI boilers silica initially rose to 30 ppm, but was overcome by intense blow-down, following which the company have experienced no difficulty in maintaining the desired level of 2 to 3 ppm.

Boiler Water Specifications

—	CEGB		ICI	
	1,500 lb per sq. in	2,350 lb per sq. in	950 lb per sq. in	1,700 lb per sq. in
Silica	3·0	1·5 (SiO_2)	< 40	2—3 (SiO_2)
Hydroxide	6·0—8·5	6·0—8·5 (OH)	80—120	20—30 (NaOH)
Phosphate	25—35	25—35 (PO_4)	100—140	10—20 (Na_3PO_4)
Chloride	20	20 (Cl)	—	—
Sulphate	20	20 (SO_4)	*	† (Na_2SO_4)
Sulphite	—	—	20—40	2—3 (Na_2SO_3)
Total dissolved salts	150	150	700—1,000	< 500

* At least 2·5 times the total alkalinity expressed as NaOH.
† Sulphate not used.

Design

DWELL-LINKAGES IN SPACE

By KENNETH H. HUNT, M.A., M.Mech.E. (Melbourne), A.M.I.Mech.E.

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IN a dwell mechanism the output member—a shaft or a slider—remains stationary for some extended period of time in the operating cycle. This kind of movement is often found in automatic machinery where, for example, intermittent feed or periodic valve operation is needed. Commonly a cam is employed, its profile shaped so as to impart the required motion to a follower.

Plane Dwell-Linkages

In certain circumstances, notably where the dwell does not occupy more than, say, one-third of the cycle time, and where there are few restrictions on the motion between one dwell and the next, the cam and follower can be replaced by a linkage. Replacement in this way may be a critical necessity at high speeds, for, in general, linkages have the advantage of operating more smoothly, and they are less susceptible to wear. In linkages there is surface contact between the elements of the lower pairs which have now replaced the higher (line contact) cam-and-follower pairs. There is no need for springs, nor for specially manufactured profiles, but the number of moving parts is more. In plane motion it is impossible to obtain a dwell linkage with fewer than five moving members (six members in all, including the frame); there is only a total of three members in a cam-follower-frame mechanism.

Plane dwell-linkages use a "coupler curve" of a four-bar chain to convert the uniform rotation of the input shaft to the required output. Figs. 1 (*a*) and (*b*) show two such linkages drawn with the output members 5 in their dwell positions. In each figure the full-cycle path of the point D on the coupler 2 is shown. This is a "coupler curve." At the dwell, the hinge between members 4 and 5 (Fig. 1 (*a*)) is arranged to lie at the centre of curvature E of the coupler curve at D. The point E can be determined fairly accurately with an atlas[1] or located by other well-known exact methods[2, 3, 4].

In Fig. 1 (*b*) a point D on the coupler is chosen which traces a curve with a good straight line section. When 5 is in its dwell position this straight line is arranged to lie along the axis of the guide for the slider 4.

Lower (Surface Contact) Pairs in Space

A linkage which is not restricted by the two dimensions of plane motion can make use of the spherical pair, Fig. 2 (*a*), and the cylindrical pair, Fig. 2 (*b*). These are both lower (surface contact) pairs and possess three and two relative degrees of freedom respectively. It is well known[3, 5, 6, 7] that the aggregate of the individual degrees of freedom in the simplest general space linkage must be seven. This basic linkage has the common four-bar chain as its counterpart in plane motion, but, since in space a lower pair may have more than one relative degree of freedom, the linkage can exist in a large number of possible forms. It may have as few as three or as many as seven members in it. Furthermore, there are numerous special geometrical cases where the aggregate number of degrees of freedom can be less than seven, but these do not influence the argument presented here.

Space Dwell-Linkages

The purpose of this article is to demonstrate that these "space pairs" can be employed in the design of space dwell-linkages which possess the advantage of having fewer members than plane dwell-linkages. The input and output shafts can still be parallel, of course, but in general there need be no restrictions on their directions and placing.

In Fig. 3 the output member 3 swings in a bearing (or hinge) fixed on the base, and it carries a cylindrical pair. The linkage is shown in the dwell position, and for the moment it is convenient to imagine the output member locked in this position and to ignore the input member. The member 2 is then free both to slide along its axis and to turn about it, and the point A can lie anywhere on the surface of the cylinder which is outlined. Oblique sections through this cylinder are ellipses, and one such section is drawn in Fig. 3. Now let the axis of the input shaft be placed so that it passes perpendicularly through this section at C, the centre of curvature of the ellipse at A. The input member is joined to A by a spherical joint and the output member is freed; the resulting space mechanism has an aggregate of seven degrees of freedom and so satisfies the general criterion. It has only three moving members.

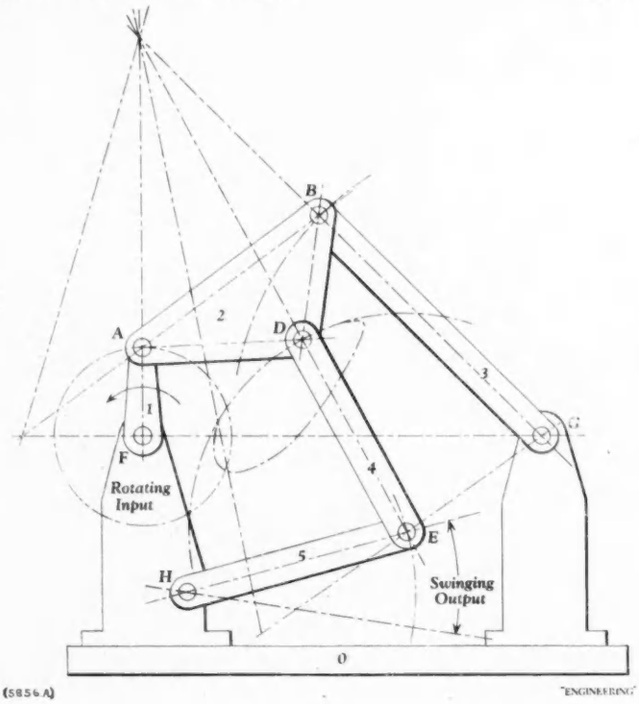
For the position shown the movement of the input shaft will not impart any angular velocity, $\dot{\phi}$, or angular acceleration, $\ddot{\phi}$, to the output shaft. If the axis of the input shaft were chosen to pass through the centre of curvature of the elliptical section at an extremity of its major or minor axis, then the fit between the circle and the ellipse would be best, because the curvature there is at a stationary value. The third derivative, $\dddot{\phi}$, would now be zero at the dwell point which would be at an extreme position of the output shaft's swing. In an actual mechanism the useful period of dwell will extend on either side of the dwell point during many degrees turned by the input shaft.

From the practical point of view the mechanism

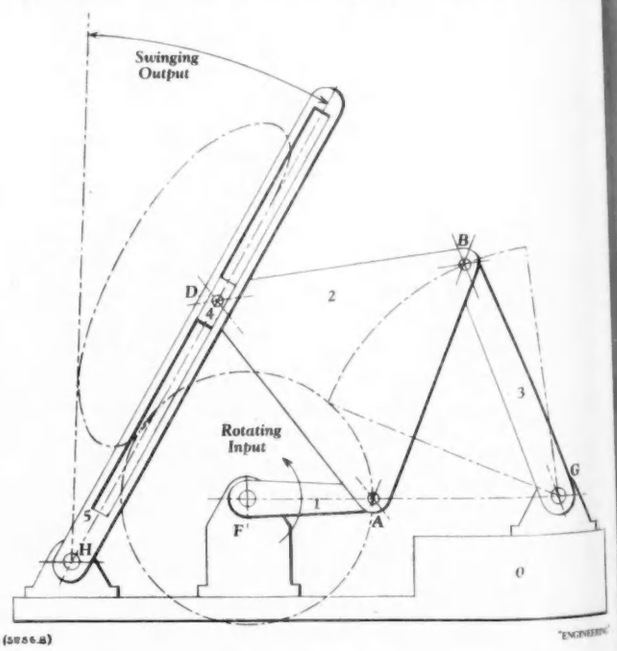
Fig. 1 Two plane dwell-linkages.

(*a*) *With hinges only.*

(*b*) *With a slider making use of a straight portion of a coupler curve.*



(5856 A) "ENGINEERING"



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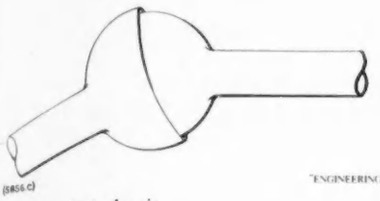
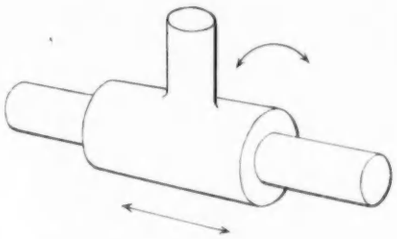


(*a*) *The spherical pair.*



(*b*) *The cylindrical pair.*

Fig. 2 Lower pairs in space.

shown in Fig. 3 is unsatisfactory by reason of the off-centre loading on the member 2 at the point A. In normal usage a slider would have the load applied on its axis to eliminate any tilting moment on it, but here the linkage depends entirely on the eccentricity of A. The cylindrical pair can be eliminated, however, and replaced by two hinges, as shown in Fig. 4; the general criterion for space mechanisms is still satisfied.

Instead of the single intermediate member 2 there are now two of them, 2a and 2b, joined together by a hinge; 2b is hinged to the output member 3; the axes of these two replacement hinges can lie in any arbitrary directions relative to one another. With the member 3 stationary, the point A must lie on a kind of toroidal surface (which would not necessarily have a circular transverse section). An oblique section through the torus would not be an ellipse but some other closed curve. As before, the axis of the input shaft is arranged to pass perpendicularly through a chosen section at the centre of curvature C of the curve at A, and the linkage is completed by a spherical pair at A.

On the same principles, it is possible to devise a third variety of space dwell-linkage in which the positions of the spherical pair and the hinge adjacent to it (Fig. 4) are interchanged and, of course, the proportions of the linkage suitably adjusted. The spherical pair is now "central" in the linkage with the two connecting members placed one on either side of it. This is not thought to be such a good mechanism as that of Fig. 4, for one of the intermediate links is now carried round in the full circle as well as the input shaft. The linkages of Figs. 3 and 4 are better suited for design without excessive movements of the connecting members, and without too much angularity in the spherical pair. Since spherical couplings are being successfully used more and more in automatic machinery, it is not felt that the necessity for them here constitutes a serious objection to this type of mechanism.

Figs. 5 (*a*) and (*b*) are drawn from photographs of actual models of space dwell mechanisms constructed according to the principles of Figs. 3 and 4 respectively. These models were built from a simple kit of standard parts. Models are often used by designers of plane mechanisms, to help them to visualise the motion through a complete cycle, but they are not essential to the experienced engineer. It would seem that they are definitely indispensable for the satisfactory design of all but the simplest of space linkages to ensure their satisfactory functioning through a full cycle without the high accelerations which result from unfavourable transmission angles[8, 9].

In this article no attempt is made to present mathematical methods for synthesising space dwell mechanisms. It is, however, not difficult to derive equations of motion with the help of vector resolution, and thus to obtain mathematical relations incorporating the desired proportions. The aim here has been merely to show that there is a methodical approach to their design, and that they are practicable possibilities.

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Fig. 3 Space dwell-linkage with three moving members.

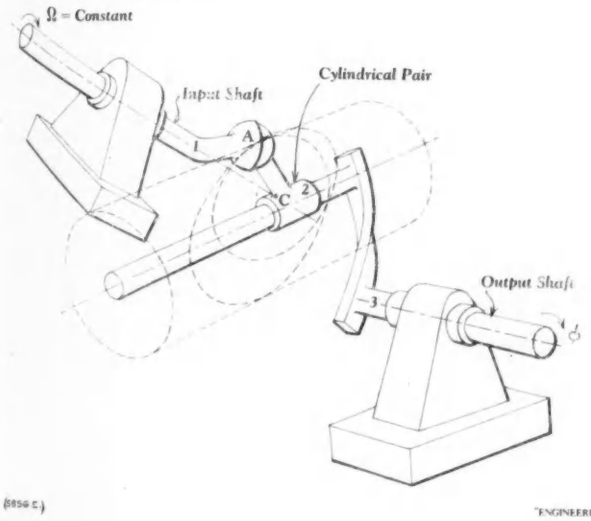


Fig. 4 Space dwell-linkage with four moving members and without a cylindrical pair.

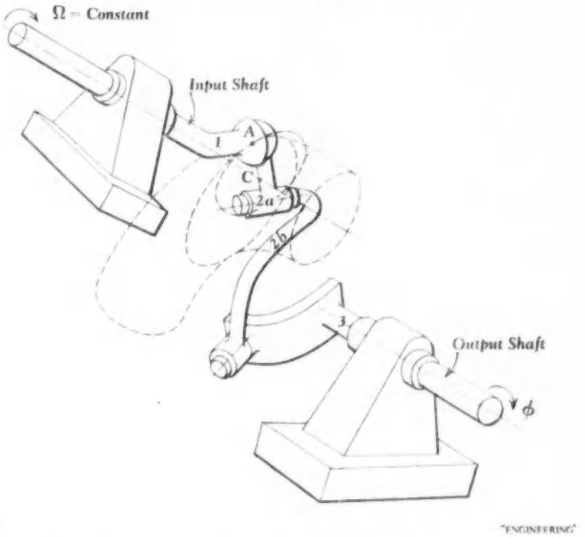
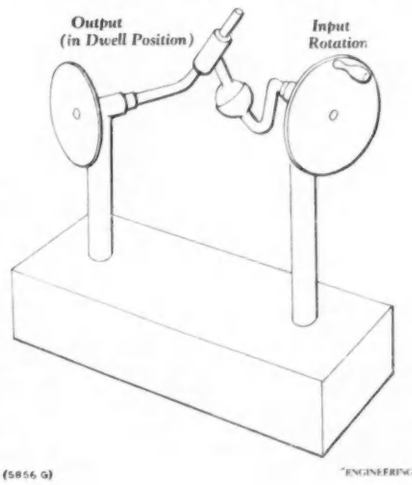
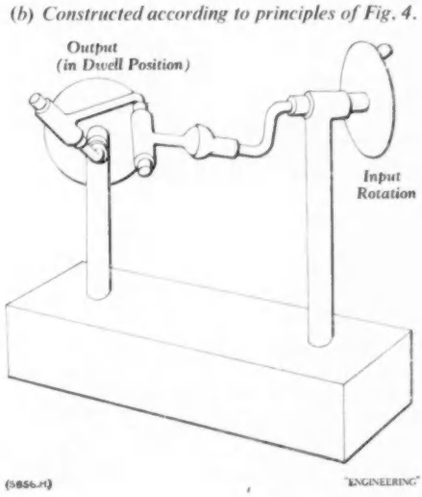


Fig. 5 (below) Working models of space dwell-linkages.

(*a*) *Constructed according to principles of Fig. 3.*



(*b*) *Constructed according to principles of Fig. 4.*



Continuing **Design**

TANKER HEATING COILS

THE shipbuilder of today has a wide choice of heating coils for installation in bunker and cargo oil tanks—mild steel, cast iron, aluminium brass and aluminium alloy coils all being in service today. Some of the more recent developments in tanker heating coils by Steels Engineering Installations Limited, Sunderland, and their associate, Archibald Low and Sons Limited, Glasgow, are described below.

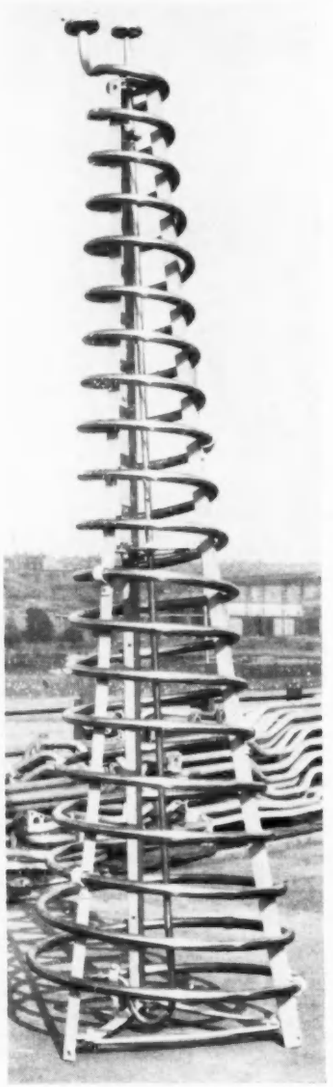
The use of aluminium brass for tank heating coil installations is becoming increasingly popular. The heat transmission properties of aluminium brass are good, and the material is remarkably resistant to corrosion in all varieties of petroleum products, and particularly to corrosion in sea water. The alloy does not develop the heavy scale which forms on steel, and impedes heat transmission. It is for this reason that reduced lineal footages are possible (12½ to 20 per cent less); allowances for impeded heat transmission caused by the crust, such as are customary in steel installations, are not necessary. Generally, tubes of 1½ in diameter are used to achieve good distribution, with reduced sizes on exhaust risers.

Aluminium brass installations are light in weight and sufficiently strong and ductile to withstand shock or injury from the ship's movement. The tubes are easily bent and jointed quickly, but it should be noted that cold bending of the tubes can cause stress.

Following the aluminium brass type of heating coil came the introduction of Alacoil aluminium alloy coils. They completely satisfy the heat transmission requirements, and are much more robust than aluminium brass. They will successfully resist shock or injury due to ship movement and, moreover, are not easily damaged by ship's crew or workmen. The coils are readily installed without alteration to the structure of the ship and any subsequent repair or alteration can be easily accomplished.

The material stands up extremely well to the corrosive effects of all petroleum products and alternating sea water ballast, and although it is more costly than mild steel it is cheaper than a similar installation in cast iron or aluminium brass. Electrolytic corrosion is successfully overcome by the use of an insulating fastening clip which also incorporates a "leak off" device to prevent any built-up of static electricity. Out of 260 vessels fitted with Alacoil up to the present day, only eight have shown signs of corrosion, all of which were found to be due to poor tank cleaning.

A complete departure from the conventional type of heating coil has recently been introduced. Developed by the Shell Group, this new design is known as the helical or conical coil, and is made under licence by Steels Engineering Installations Limited and Archibald Low and Sons Limited. Whereas all previous tanker heating systems consisted of grids on the bottom of the tank, the new concept in tanker heating comprises a number of vertical spirals, the number being dependent on the cargo carried and the size of each tank.



A helical coil unit fabricated from 1½ in bore 14 s.w.g. aluminium brass tube.

Some coils have been subjected to extensive sea trials and have proved very successful. Heat emission is outstandingly good and, in fact, the conical design is claimed to have a far greater heating effect than conventional grid coils. The recommended materials for helical coils are aluminium brass or, if cathodic protection is contemplated, mild steel tubing.

Helical units differ in height, diameter, number of spirals, and in pitch distance, since such factors are dictated by access to tanks through manholes, deck connections, heating surface specified, tank capacity, etc. Two fundamental principles will always be applied: (*a*) helical elements must decrease in diameter from base to head for efficient cumulative effect of convection currents in the liquid over wide areas; (*b*) to eliminate waterlogging, each element must have a separate condensate outlet.

When heating of cargo is not required they can be readily dismantled at a low cost. The self-contained units can be conveniently stored and used again when a charter requires cargo heating and they can be made interchangeable so that they will fit all ships of the same fleet.

An important incidental result of the development trials of the helical form of coil was a very clear indication of the advantage of continuous heating. The maintenance of oil cargo at a temperature approximating to pumping temperature showed appreciable economies in steam, by comparison with the normal procedure of heating up from cold over a relatively short period in preparation for discharging.

PORTABLE HEATING GRID

The most recent development in tanker heating is the production of portable heating grids in block form. Using Alacoil aluminium alloy tubes, Steels Engineering Installations Limited have produced a complete portable unit which can be lifted in and out of a cargo tank quickly and easily.

The advantage of this design is best seen in relation to modern ore carriers consistently used for alternating cargoes of ore and oil. The comparatively simple removal and storage of the block coil in one lift is obviously more economic than either dismantling, removal and storage, or covering with wood ceiling, the conventional flat grid coils.

A portable heating grid made from Alacoil aluminium alloy tube. This unit is being supplied for an oil/ore carrier under construction in Japan.

Units manufactured so far are approximately 30 ft by 9 ft, mounted on a frame of aluminium extruded channel sections with the Alacoil tubing mounted both above and below

The unit is fixed centrally in the cargo tank and connected to the steam supply and exhaust at the bulkhead. When not in use it is fixed to the top of the hatch cover. The entire frame and installation is fixed to the bottom of the tank by insulated bolts, and rests on insulating pads. Thus the complete installation is insulated from the tank and ship's shell.

The grids can be quickly and easily removed when the holds are to be used for ore cargo. The flanges are released, eight bolts removed and slings attached to four bridles, which form part of the centre aluminium frame, and the complete unit is lifted out of the tank.

These portable grids, while retaining the advantages and characteristics of the Alacoil system, are also lighter in weight and easily installed or removed. They may also be fabricated from aluminium brass tubing or mild steel if cathodic protection is contemplated.

Concluding **Dwell Linkages**

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Marketing

Outward from the Centre

The activities of the Engineering Centre, Birmingham, are continually expanding and the management have recently taken a step to render the Centre's services more widely available. A new class of membership has been created, enabling British engineering firms to become associate exhibitors for a fee of 10 guineas a year.

The Centre's information department, which has continually expanded since its formation in 1954, is now in direct touch with some 5,000 engineering firms, handling inquiries on products, sources of supply, production capacity, etc. Its catalogue library carries the up-to-date literature of some 4,000 firms. Stimulated by its activities at overseas exhibitions, the Engineering Centre receives visitors and inquiries from all over the world. These are carefully analysed before being diverted to the appropriate firms, and some measure of the quantity handled is indicated by the fact that over 1,500 firm trade inquiries were reported to have been taken on the Centre's group display at the recent Brussels Exhibition.

Mr. A. J. Cox, general manager of the Centre, announced recently that spaces have been reserved at the British Trade Fair, Lisbon (29 May to 14 June) to enable 25 firms to exhibit there. The Engineering Centre is undertaking the organisation of the firms' exhibits for an all-inclusive charge ranging between approximately £40 and £175 according to size. Mr. Cox added that he believed that, in providing this scheme and undertaking the organisation of the firms' exhibits and their transport to and from the Fair, plus the layout of the stands and staffing them where necessary, the Centre would enable firms to investigate the Portuguese market or to consolidate their position there with the minimum of trouble and cost to themselves.

East German Exchange

A trade agreement for the exchange of £7 million worth of goods between Britain and East Germany was concluded recently after discussions in London between the Federation of British Industries and the East German Chamber of Foreign Trade.

The plan provided for an exchange on both sides of raw materials, semi-manufactures and finished goods. Included are about £2 million worth of imports by both parties under licence and the purchase through London of goods of non-United Kingdom origin to the value of some £3½ million. British exports to East Germany will include textiles, plastics, chemicals, iron and steel, scientific instruments, radio and television equipment, and industrial plant and machinery. East Germany's exports to us are to include chemicals, fertilisers, paraffin wax, carpets, furniture, pottery and porcelain, musical instruments, scientific instruments and machinery.

Australia's Hopes

Latest reports from Australia suggest that the Australian Government are sticking to their policy of banking on economic recovery. The Cabinet will soon be reviewing their import policy for the new licensing year which begins on 1 April. It now appears unlikely that a return will be made to the policy of making large-scale cuts in imports which was adopted in previous crises. The import ceiling will probably be held at the steady level of £A800 million, where it has remained for about 18 months.

There are a number of factors in this " better than expected " turn of events. First is the relatively low drain on Australia's international economy resources, helped by a sudden increase in the inflow of new capital (from £A36 million in the second half of 1957 to £A73 million within the first half of 1958) and by Government borrowing of almost £58 million in London and New York. The shrinkage of international resources was thus reduced to £A25 million from about £A120—140 million expected over the whole financial year 1958-59. Another factor is the active state of the Australian economy, particularly in manufacturing industries where the major investment has been made.

The dominant consideration of the Australian Cabinet in their review of trade policy will doubtless be the confident anticipation of a world economic recovery—fairly definite in North America and tentative in Western Europe —which will produce a rising market for Australian exports and help to secure a better wool cheque. Currency reserves now stand at about £A500 million, substantially above the safety level. The fact that £A212 million was added during 1956-57 shows how potent are wool earnings from exports.

Glass to New York

British industrial glass is to be sold in the United States and distributed on a national scale. An agreement has been concluded between QVF Limited of Fenton, Stoke-on-Trent, and Corning Glassworks, of Corning, New York, whereby the latter will act as stockists and distributors of QVF products.

The new arrangement was concluded during a visit to the United States by QVF's managing director, Mr. Brian Turpin, and Mr. J. G. Window, their sales director. QVF expect considerable sales to result from the agreement. Already they have shipped industrial glassware to the value of £10,000 as part of an initial order. Mr. Window anticipates " a very considerable demand," particularly for QVF designs of heat exchangers. Also their 200-litre glass flasks are the largest made and Corning are confident they will sell well.

Export Prospects Suffer

A further deterioration in some of the United Kingdom's best markets marked the last quarter of 1958. Trading opportunities for British exporters have become worse since October in seven countries—Australia, Denmark, Finland, Netherlands, Pakistan, Spain and South Africa. Only in Ceylon are there signs of an improvement.

Taking the 34 principal markets for British products there was a definite turn for the worse. In 1956, for instance, the number of countries where the outlook was " good," or " improving " totalled 20: by January, 1959, this number had shrunk to 15. During the same period, the number of countries whose prospects were " bad " or " deteriorating " rose from 14 to 19.

These figures, which are the result of a continuous analysis of export prospects by the General Electric Company, are published in the current issue of *GEC Export Guide*. The guide provides each quarter the latest available information in this country on the export prospects of 36 major groups of manufactured goods, together with an indication of current economic and commercial conditions in overseas countries. The current situation reflects quite clearly the effect of a long period of low commodity prices on primary producers, particularly Commonwealth countries. These low commodity prices followed the American recession and were affected by the deepening recession in Western Europe. All principal European markets are in the " deteriorating " or " bad " categories, with the exception of Portugal, where prospects are good, and Sweden, where they are improving.

There is little doubt that British exports will fall during the current quarter. The extent of the fall will be vitally affected by the price movement of leading comodities and the amount of the confidence generated by the recovery in North America.

European Foothold

Many British firms are keenly aware of the deterioration which has taken place recently in British export prospects in Western Europe due to the advent of the Common Market, and some have acted in anticipation. The tendency, which is gaining momentum, is to gain a manufacturing foothold (i.e., to invest or obtain a stake in Common Market development) on the other side of the tariff wall, generally in co-operation with a Continental firm.

An example of this is provided by British Industrial Plastics, who are currently negotiating with Algemene Kunstzijde Unie (AKU) to set up a joint subsidiary in the Netherlands to manufacture plastics for sale in Common Market countries. The move is not finally agreed but is very likely to go through. It is prompted on BIP's part by the wish to have a bridgehead within the Common Market and so allow their products to compete on equal terms.

AKU are prompted by a different motive: they are the largest makers of man-made fibres in Benelux and the fourth ranking company in Holland. Like Courtaulds in this country, they have been keen to diversify their interests and the deal offers them an opportunity to enter the fast-growing plastics industry with the considerable advantage of BIP's experience and technical resources. This is the kind of deal which will appeal to other companies in BIP's position.

Cutting Prices

To the momentum towards lower prices given by falling costs of raw materials has been added in some cases the full force of competition following the ending of various price agreements. On the first day of free cotton yarn prices for more than 20 years, quotations recorded substantial all-round falls, with the greatest decline in the finer qualities. These falls resulted from the formal ending by the Restrictive Practices Court of the Yarn Spinners Association's agreement.

Cheaper raw materials and improvements in production facilities are given as the main factors in widespread price reductions by Boots the Chemists. The reductions range from 6½ to 20 per cent and cover eleven of the company's branded products. Reductions affecting twelve other branded products were made last September.

The downward trend of prices continues in the electrical engineering industry. Siemens Edison Swan announced substantial reductions of the prices for many of their Edison-Mazda television tubes and valves, made possible " by improved manufacturing methods and the use of high speed automatic equipment." Lamp prices have also been reduced, and both AEI and Crompton Parkinson have cut theirs substantially. Forty and 60 watt lamps have been reduced from 2*s* 5*d* to 1*s* 11½*d* each and comparable price cuts made in most other sizes. " Improved production techniques " are given as the reason for this encouraging development.

Book Reviews

FEEDBACK ENGINEERING

Analytical Design of Linear Feedback Controls. By GEORGE C. NEWTON, JR., LEONARD A. GOULD and JAMES F. KAISER. *John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, N.Y., USA.* ($12); and *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (96*s*)

Feedback Control Systems. By OTTO J. M. SMITH. *McGraw-Hill Book Company Incorporated, 330 West 42nd Street, New York 36, N.Y., USA.* ($12·50); and *McGraw-Hill Publishing Company Limited, 95 Farringdon Street, London, EC4.* (101*s* 6*d*)

Feedback Theory and its Applications. By P. H. HAMMOND. *The English Universities Press Limited, 102 Newgate Street, London, EC1.* (35*s*)

The design of feedback control systems for use in industrial processes, instruments, aircraft control, and many aspects of military engineering is of ever increasing importance and the flood of papers and textbooks now appearing testify to the large number of workers in this field. A feedback control system is generally used when one physical quantity, the output, has to be related in some way to another measured physical quantity, the input, in the presence of disturbing forces. Quite often the system is required to reproduce at the output the variations of the input as faithfully as possible.

The elements forming the complete system usually fall into two groups, first the fixed elements whose dynamic characteristics are hardly susceptible to much alteration by the control engineer and second the non-fixed elements whose characteristics can be changed by the designer and which are therefore utilised to produce the final system satisfying specified requirements. The group of non-fixed elements are often called the controller, or, in the case when the input is constant and the output supposed to be constant, the regulator. The fixed elements can be almost any dynamic engineering element from an electric motor with its shaft load as in a servomechanism, to an aircraft in an auto-pilot control system, or to a chemical plant in a process control system. If the fixed elements had no vagaries of their own, or to put it more precisely were not susceptible to uncontrolled disturbances of a more or less random kind there would be no need for a feedback control system. In fact many instruments do measure one physical quantity in terms of another very satisfactorily without using a feedback loop. In general, however, feedback control systems are used in situations where disturbances are present and their essential property is that they minimise the effect on the output signal of disturbances which enter the system and which do not themselves form part of the ideal input signal.

The design of a control system amounts to choosing the non-fixed elements, and the final design will depend markedly on the specifications of the input and output signals as well as on the characteristics of the fixed elements and the disturbances. In a linear system the disturbances, after suitable modification, can be assumed to act at the input to the system so that the actual input is the sum of the ideal input signal and the disturbances. The output signal, therefore, never corresponds exactly to the ideal input and a specification for the actual output must express in some way the allowable variations from the ideal output signal. The ideal input signal is sometimes postulated in simple form such as a step function, ramp, or sine wave, but since these are seldom actual inputs it is better if possible to specify the real randomly varying input in terms of statistical characteristics, such as amplitude distribution and power spectrum; usually intelligent guesses for these quantities are acceptable. The disturbances might also be specified in similar way.

The complete control system has many of the characteristics of a filter, its object being to filter out disturbances so that the output depends only on the ideal input. This can never be done with complete success, but Wiener showed some years ago that there was an optimum filter for any combination of signal plus disturbances provided the characteristics of each were known. Very little use has been made of this discovery until recently, mostly because the theory was presented in a very general form. However, by introducing restrictions on the properties of signal and noise the application of the theory can be made much simpler, as shown by Darlington and also by Newton, without restricting the engineer's freedom of design in any marked way.

Up till now most control systems have undoubtedly been designed by one or other of the processes familiar to most control engineers which can be lumped together as trial-and-error methods. Given specifications for input signal, output signal and allowable variation, disturbances, stability, and the fixed elements the designer usually considers first a simple feedback system containing the fixed elements, an amplifier and the feedback path, and if this cannot satisfy the requirements, additional elements with known amplitude-frequency characteristics are added. If this is not successful the procedure is repeated until it is. The success depends largely on the specifications for the variables for they may or may not be consistent with themselves and the properties of the fixed elements. If they are not then much unrewarded effort may be expended by the designer before he gives up. Also if a solution is obtained it is by no means clear whether it is the optimum solution in any way or even the most economical. Therefore rightly much attention is being paid nowadays to the design of systems which are optimum in some sense and in which the consistency of the specifications becomes apparent during the design. Optimum design means that some property of the system is minimised (or maximised) by the provision of non-fixed elements with suitable parameters. Typical criteria used are the minimisation of the output error power and the minimisation of the time integral of the error squared, it being assumed statistical properties are used to describe the variables. Progress has been such that two of the textbooks being reviewed describe in some detail this type of design or synthesis.

Progress in feedback control theory and practice is continuing through the efforts of engineers in industry and in the universities and many of the latter group have realised that the concept of a feedback system is an engineering idea which should be basic knowledge for anyone interested in dynamic engineering systems. It may also have important uses outside engineering science, for example, in economics and sociology. The theory usually deals with an abstract from a real situation in the same way that circuit theory deals with an abstract from a real electrical system, but in the same way too the real situation can be represented more and more closely by using a more complex representation. It is proper therefore to teach feedback theory as an independent concept illuminated by examples from various practical situations. The three books reviewed here approach the subject from this point of view assuming a fair background of engineering science, and in particular of elementary electrical engineering. This knowledge of electrical circuit theory is not absolutely essential for a study of these three books, but it helps and it is noteworthy that all the authors are electrical engineers or have been trained in this subject.

Mr. Hammond's book is mostly concerned with the analysis of simple feedback systems with examples drawn from electronic amplifiers and servomechanisms. Professor Smith gives an extended and detailed account of many analytical and synthetic methods applied to linear and non-linear systems, whilst Dr. Newton and his co-authors set out to develop a systematic method of designing linear control systems. Mr. Hammond's book could be used for a first course such as might be given to honours students in electrical engineering, but the other two books are more suitable for postgraduate students and designers.

The first published, and in the reviewer's opinion, the most exciting book of the three is that by Dr. G. C. Newton and his colleagues. Dr. Newton is well known for his work at Massachusetts Institute of Technology on control systems and in his book he sets out to develop a design method for linear control systems. This design method is based on the minimisation of the time integral of error squared,

$$I = \int_{-\infty}^{\infty} x^2 dt$$

where $x(t)$ is the error between the actual output and the ideal output. The minimisation of I depends on the alteration of the non-fixed elements although firstly the overall characteristics of the controller are obtained and the choice of the actual hardware is in the hands of the designer. A linear system is only linear provided the system variables remain within fixed bounds and there is always some condition at which the linear system becomes non-linear. This might be when the maximum possible power is being delivered or when some element saturates and its output no longer changes as its input increases. Dr. Newton is able to embody this type of contraint into his design procedure so that the final system devised tends to operate so that saturation levels are not reached. Furthermore, if the specifications for allowable error are such that saturation or lack of power will always prevent them being met his procedure will display this fact. The mathematics involved in this procedure, which is based on expressing the integral I in terms of frequency by Parseval's theorem, although not too difficult can be very laborious, especially when the signals are described statistically. It is to be hoped that tables or charts can be prepared to reduce some of the computational labour required. In the book is an excellent account of the trial-and-error design method; and Dr. Newton's method, based on Wiener's filter theory, is very clearly explained in the earlier chapters. The chapter entitled the Design of Control Systems for Minimum Bandwith comes at the end of the work and is possibly the least satisfactory part of the book and the reviewer would have liked this section amplified somewhat. The last chapter is a most interesting one and deals in a most lucid manner with the design of a control system needed to position a large radio-telescope accurately. The whole discussion is very thorough and illuminated time and again by the engineering skill undoubtedly possessed by the authors. An excellent series of appendices on various mathematical topics closes the book which should be read by all serious students of modern sophisticated control theory.

Professor Smith's textbook is much the most ambitious book of the three for it sets out to present all the most important methods used to analyse and design linear and non-linear control systems. Surprisingly enough it is quite successful in this aim and one can only wonder at the industry and capabilities of the author in collecting and presenting this material. This book is a textbook for advanced students such as those who might be attending a postgraduate course or

for engineers with some knowledge of the subject who wish to survey the whole field. It is divided into four parts: linear analysis, linear synthesis, steady-state non-linear analysis, and non-linear synthesis and there are 18 chapters in all. There is an amazing amount of detailed and well presented analysis and the range of topics is very wide. Single loops, multiple loops, systems with distributed parameters, relay systems and carrier systems are discussed with the aid of transient analysis, frequency analysis, and statistical methods. Each method is explained fully and little previous knowledge of the mathematical methods is required. In particular the reviewer found that the sections on synthesis or design of particular value and would be very suitable reading for a research student about to begin studies of this nature, or for an engineer in industry wishing to extend his techniques. Each chapter has a reasonable bibliography containing the most important books and papers on its particular topic, although there are notable exceptions now and again but these references are seldom dated after 1955. Misprints seem to be very few indeed and the book can be recommended as a valuable compendium of reasonably up-to-date information on control engineering and as a possible textbook for an advanced course. It does suffer, however, from a lack of a critical approach and more emphasis should have been placed on selecting analytic or synthetic methods which in the author's opinion were of most use.

Mr. Hammond's book is the least ambitious of the three and the shortest in length. It is easy to read and should be well within the grasp of the student or engineer it is aimed at, namely the graduate who is studying control or feedback systems for the first time. It has a very definite electrical bias as might be expected from the background of the author, who is a well-known member of the staff at the Radio Research Establishment, Great Malvern. The treatment of stability is adequate rather than rigorous insofar as linear systems are discussed, whilst the stability of non-linear systems as exemplified by an on-off servomechanism is very restricted. In fact the value of the book would not have been reduced if the chapter on relay servomechanisms had been omitted. A discussion of the real non-linearities which are always present in nominally linear servomechanisms would have rounded off adequately a book mainly concerned with linear systems. A chapter on simulation techniques and analogue computers is included and to each chapter is appended a short bibliography. This book is not highly priced, and could be profitably read by undergraduates studying electrical engineering, as well as the graduates it is aimed at.

All three books are excellently produced by their printers and the typescript is easy to read.

GROPING FOR AUTOMATIC AIDS

Automation in Production Engineering. By J. A. OATES. *George Newnes Limited, Tower House, Southampton Street, Strand, London, WC2.* (45*s*)

The excellence of the reproduction of this book its lavish illustration, and its price combine to give a first impression that here is a work which will give real guidance to those requiring help in the assessment and selection of automatic aids in manufacture.

After the briefest introductory chapter, which whets the appetite for more, the book dives straight into a detailed description of pneumatic and hydraulic feeding and clamping equipment, and thenceforward the pattern is established. Although the whole field of machine shop endeavour is covered, the emphasis is almost entirely on education by description. Each chapter opens with a brief factual statement of its scope, sometimes amounting to no more than two or three lines, and then goes on to give a more detailed description, usually with acknowledgments to the manufacturer, of a piece of special-purpose equipment. By its very nature, the textual descriptive matter, while certainly having no advertising or publicity bias, is by no means critical, and as such it can be of little assistance to the reader who is honestly seeking guidance.

The thoroughness with which the author describes the details of pneumatic, hydraulic and electrical circuits; automatic loading and unloading as applied to certain proprietary machines; the operation of proprietary automatic grinders, copying lathes, hobbing and shaving machines; Solex and Sigma automatic size control and gauging systems; and transfer machines, leaves one a little puzzled as to who the book is intended to help. Few, if any, user firms would find it economical to design their own equipment when so many developed machines already in production are available. The student requires a textbook, which this emphatically is not, and he will find it an expensive collection of catalogues, which it more nearly is.

Five-sixths of the book have been taken up as described, before the control of machines by magnetic or punched tapes is dealt with, and here the shortcomings become even more obvious. The painstaking descriptions of the various systems of control are certainly useful, but there is nothing to guide the would-be user, nothing on the relative merits of the different systems, nothing but the briefest mention of the time to be saved, and little more than a passing reference to the preparation of co-ordinate dimensioned drawings.

Finally—and this is surely the most serious omission in any book dealing with automatic or production engineering or manufacture of machining—nowhere is the question of cost discussed at all, whether prime cost of equipment, cost of installation, of setting up, or operation or of maintenance. In fact, the word "cost" does not appear in the index at all, which leaves one reader in serious doubt as to whether the cost of this expensive publication can, in fact, be justified.

NEW BOOKS

The Design of Right Concrete Slab Bridges for Abnormal Loading. By R. E. ROWE. *The Cement and Concrete Association, 52 Grosvenor Gardens, London, SW1.*

Preparation of Samples for Microscopic Investigation. By ERVIN POULSEN. Progress Report No. M1. *The Danish National Institute of Building Research and the Academy of Technical Sciences Committee on Alkali Reactions in Concrete, 20 Borgergade, Copenhagen K, Denmark.*

Reflex Reflectors. By K. N. CHANDLER and J. A. REID. Road Research Technical Paper No. 42. Published for the *Road Research Laboratory, Department of Scientific and Industrial Research*, by *Her Majesty's Stationery Office, York House, Kingsway, London, WC2.* (2*s* 6*d*)

The Specific Surface of Concrete Aggregates and its Relation to the Workability of Concrete. By B. W. SHACKLOCK and W. R. WALKER. Research Report No. 4. *Cement and Concrete Association, 52 Grosvenor Gardens, London, SW1.*

On the Shelf

By Frank H. Smith

If I start talking about film I shall have to rename the column "Between the Gates" or "On the Spool" (no spool like an old spool), but an occasional mention cannot hurt. GB Film Library of Aintree Road, Perivale, Greenford (a Rank insider) have a pamphlet "Film News" of which the latest is an edition specialising in industrial training films. With it goes a separate list with hire charges and/or purchase prices. All this is dated April, 1958, so what I am doing with it now I do not know. Poor salesmanship I suppose. I'd better go to the flicks.

At a penny a line I take delight in mentioning the Deutsche Gesellschaft fur chemisches Apparatewesen and its 8th installment (sic) of the Dechema-Werkstoff-Tabelle at DM40. It once again represents a contribution of 100 pages of precise data on the chemical resistance of about 100 constructional materials to 46 corrosive substances. The final work will be 1,200 pages, and if you want to know more write to Dechema-Haus, Frankfurt am Main, Rheingau Allee 25.

Dated December, 1958, is No. 1 of Volume 1 of the College of Aeronautics *Gazette*. This is the official journal of the College and not to be confused with the students' *Potential*. The *Gazette* consists of Introduction, Diary, Personalia, Appointments and list of personalities connected with the College gubernatorially, academically or administratively. No price.

Without comment I offer a folder from Los Angeles entitled "A revolutionary new totally cross-referenced index—and it will be produced at the speed of light." This refers to *Pilot*, a "permutation index of this month's literature on electronics, computers, automation, avionics." $60 is the annual rate—for further particulars write to Sol Grossman, President, Permutation Indexing Inc., PO Box 25075, Los Angeles 25. Satisfaction with first issue or money back.

One notices (if one reads the *Soviet News*) that a State Public Library of Technical Sciences under the State Committee for Technical Sciences is to be set up in the USSR. If only half of this is to be the library's title it will run our two projected efforts a close second and it now remains to be seen which gets cracking first. (Excuse the vulgarism but I am never sure whether it should be "under way" or "under weigh.")

Pergamon contemplate "Planetary and Space Physics" under their usual arrangement of two subscriptions. The "body" rate is £7 per volume and the individual is half that. Further particulars from 4/5 Fitzroy Square, London, W1.

One notices in January, 1959, of the *Computer Journal*, correspondence on "DEUCE Interpretive Programs." This is from an English Electric correspondent and I respectfully suggest he put two of those three words through his own computer.

I am sorry that my dilatoriness has cost you £12. Had you ordered the complete proceedings of the IVth International Congress of Biochemistry before 1 February, the 15 volumes would have cost you but £36. Now they'll cost £48 (from Pergamon).

I do wish I could tell you about *Energija*, of which I have just received Broj 9 (or is it Godiste 7). I suspect that if you drop a line to Zagreb, Ulica Proleterskih brigada 37 you will hear all about it. I think the price is about Din 2500 a year. Why not ring 51-822?

I have the first (January, 1959) LLU Translations Bulletin (HMSO 4*s*) issued by the DSIR (there's a lovely collection of initials). This really is a most interesting booklet and those who are not prepared to risk 4*s* for a sample may be able to get a copy of the press release from DSIR, Charles House, 5-11 Regent Street, London, SW1 (WHItehall 9788).

Operation and Maintenance

STABILITY LIMITS *Operation Tests on 60 MW Alternator*

SOME very informative results have been obtained from an extensive series of tests recently carried out on a 60 MW direct-cooled turbo-alternator installed by the GEC in the Poole Generating Station of the Southern Division of the CEGB. Many synchronous and asynchronous running tests were made to examine the behaviour of the regulator system shown in Fig. 1 under different conditions and to check its performance under rotor-angle control instead of terminal voltage control. The opportunity was also taken to obtain data on machine characteristics not normally available, such as the measurement of the quadrature-axis synchronous reactance, the running as an induction generator with several field circuit connections, and the performance of the unit under conditions of coarse synchronising. Analysis of the many oscillographic records must take some time but it is possible to make at this stage some preliminary comments on a few of the more interesting results.

THE PLANT

The alternator is a 60 MW machine with direct rotor cooling and the first to be commissioned in Britain designed to operate at a hydrogen pressure of 30 lb per sq. in. The physical size of the unit is much smaller than that of a conventionally cooled machine of the same rating. The gear-driven exciter runs at 1,000 r.p.m. with an overhung 400 c/s homopolar alternator to supply the automatic voltage regulating (AVR) equipment. Since there is no other rotating plant the total amount of brush gear is reduced to the exciter armature and the alternator rotor sliprings.

The voltage regulator is a type CVR7 magnetic amplifier continuously acting regulator employing a double neon reference tube circuit for high reliability and accuracy. The voltage error is amplified by two primary amplifier stages and controls a final magnetic amplifier of 12 kW peak output for supplying the field of the main exciter. The overall gain is such that the terminal voltage is regulated within 0·5 per cent of the set value. A fixed negative bias field is supplied to the exciter in order to improve the voltage bucking performance of the equipment.

The rotor angle limiter type KAL (incorporated as a standard feature), receives its signal from a permanent-magnet alternator on the shaft, so that an accurate indication of the rotor angle is obtained both during steady state and transient conditions. Once the set rotor angle has been exceeded, a strong boosting signal proportional to the excess angle is applied to the amplifier chain with sufficient gain to convert the equipment virtually into a rotor angle controller.

On hand control an induction regulator is used to adjust the signal winding of the main magnetic amplifier. On automatic control, the same regulator follows up the AVR excitation setting so that a rapid changeover back to hand can always be effected without disturbance. The overriding principle has been to design a static regulator system with the maximum simplicity and reliability.

Oscillographic records were taken of machine terminal voltage, stator currents, MW and MVAr outputs, rotor current, exciter voltage and field current, rotor angle, speed, governor travel and input steam pressure. The initial and final values of most of these quantities were recorded by sub-standard instruments specially calibrated and installed for the tests by the metering section of the technical department of the Southern Division, CEGB.

The rotor angle indicating instrument which forms part of the normal AVR equipment is scaled from 0° to 160°. This meter, which is installed in the control room, proved of great value during the tests. A second instrument was provided to indicate the overall transmission angle between the rotor and the 132 kV busbars, and both meters agreed in general to within 1° with readings taken by stroboscopic shaft equipment. This equipment, developed and operated by the London Division of the CEGB, provided recordings and a running commentary which considerably facilitated the control of many of the tests.

Altogether, over 70 tests were made during the week, and a great proportion required initial and final readings plus a transient record. Full evaluation of the records will give new insight

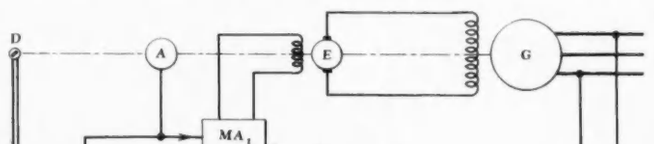


Fig. 1 Basic diagram of automatic voltage regulator type CVR 7 with rotor angle limiter type KAL

A 400 c/s. pilot alternator.
D Permanent-magnet rotor angle transmitter.
E Main exciter.
G Main alternator.
H Hand follow-up circuit.
IR Induction regulator.
L Rotor angle limiter.
M Hand-control induction regulator motor.
MA_1 Main magnetic amplifier.
MA_2 Second stage amplifier.
MA_3 First stage amplifier.
Ne Neon reference circuit.
S_1 Hand/auto changeover relay.
VT Voltage transformer.
e_t Terminal voltage.
e_r Reference voltage.
i_{AVR} Regulator control output signal = $K(e_r - e_t)$.
i_H Hand control signal.

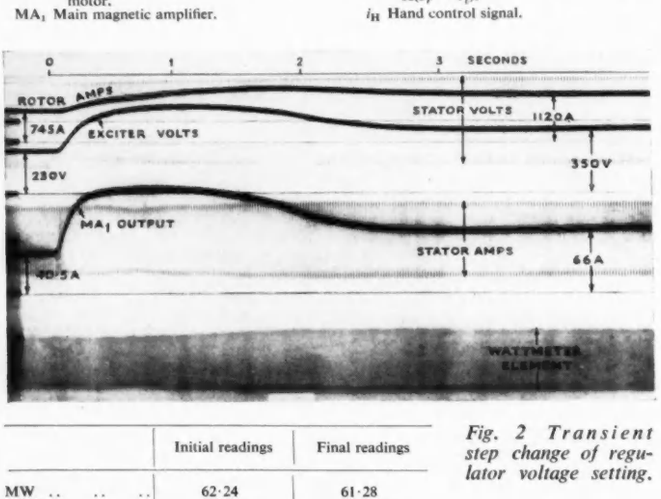


Fig. 2 Transient step change of regulator voltage setting.

	Initial readings	Final readings
MW	62·24	61·28
MVAr	1·0 lag	43·6 lag
Stator voltage ..	11·2 kV	12·3 kV
Stator current ..	3,200 A	3,568 A
Load angle	66 deg.	40 deg.

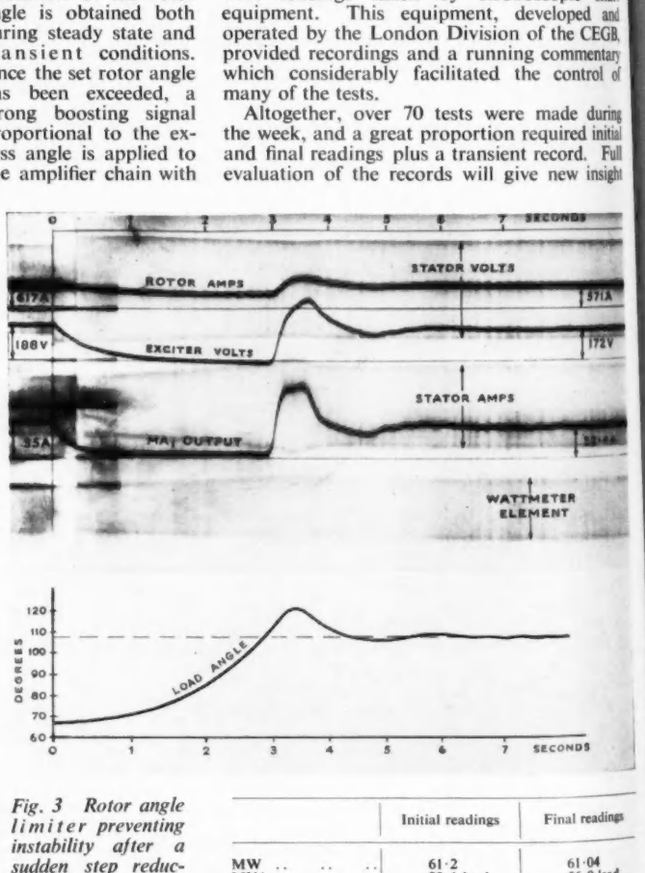
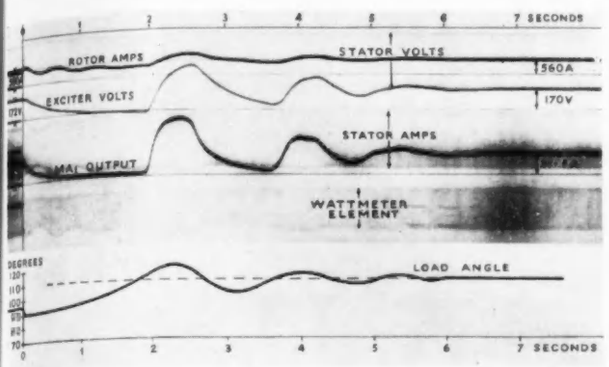


Fig. 3 Rotor angle limiter preventing instability after a sudden step reduction of the regulator voltage setting.

	Initial readings	Final readings
MW	61·2	61·04
MVAr	20·1 lead	56·0 lead
Stator voltage ..	13·0 kV	11·93 kV
Stator current ..	2,850 A	3,955 A
Load angle	66 deg.	107·5 deg.



	Initial readings	Final readings
MW	58·72	58·8
MVAr	31·4 lead	57·6 lead
Stator voltage	11·45 kV	11·88 kV
Stator current	3,330 A	3,960 A
Load angle	95·5 deg.	109·5 deg.

Fig. 4 Rotor angle limiter preventing instability after line switching disturbance.

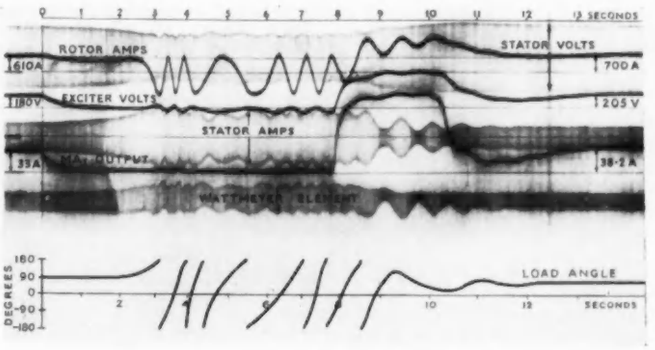


Fig. 5 Restoration of synchronism by switching to AVR control after removal of field at 60 MW.

	Initial readings (before removing field)	Final readings
MW	60·64	58·0
MVAr	33·5 lead	0·7 lead
Stator voltage	11·05 kV	12·12 kV
Stator current	3,600 A	2,750 A
Load angle	94·5 deg.	59 deg.

into the performance of synchronous machines under many unusual conditions and methods of control.

THE TESTS

Transient Performance.—The response of the excitation system to a sudden change of voltage setting is shown in Fig. 2, where the change of signal was such as to alter the generation from 60 MW unity power factor to 60 MW, 45 MVA lag (i.e. 0·8 p.f.). The rapid rise of the main exciter field current indicates clearly the high performance obtained from the 400 c/s magnetic amplifier chain. The terminal voltage can be seen to have attained its final value well within two seconds. The initial dip in the terminal voltage trace is caused by a change of sensitivity applied to this trace as an indication of the instant when the transient kick is applied to the regulator.

Rotor Angle Limit Control.—The rotor angle limiter is a continuously acting device whose operation may be considered equivalent to that of a stiff spring-loaded buffer, so that if the rotor tends to move beyond the set angle a signal proportional to the excess angle is applied to the AVR to boost the excitation to prevent further increase of angle. This was demonstrated with the unit on 60 MW by adjusting the rotor angle limiter to 70° and then reducing the AVR setting until the rotor angle approached this value, when the limiter began to have some effect. The first action was the bringing up of the rotor angle alarm. Subsequent reduction of the AVR setting down to the minimum had negligible effect on the terminal voltage and rotor angle. The alternator excitation was now completely determined by the rotor angle limiter equipment and by altering the adjustment of the limiter, the alternator could be moved round to any load angle within the range of stable operation under normal AVR control. This in effect meant that the alternator was on rotor angle control instead of voltage control.

Tests were then conducted to determine the ability of the limiter to prevent a machine falling out of step under adverse transient conditions. One of these tests was to start with the alternator running at a normal load angle at 60 MW and suddenly to reduce drastically the AVR setting, giving a resultant zero field voltage on the alternator. Under these conditions the rotor angle limiter invariably provided a " buffer " to the rotor as it attempted to fall out of step, and correctly held the machine on the limiter equipment. An example of this is shown in Fig. 3.

A further interesting example of a practical application of this is shown in Fig. 4, where the rotor angle limiter has prevented loss of synchronism due to the line switching disturbance described below. This is of great interest as it demonstrates that if a set is running at a high angle near the stability limit, the rotor angle limiter can ensure that no adverse system switching can cause the machine to fall out of step.

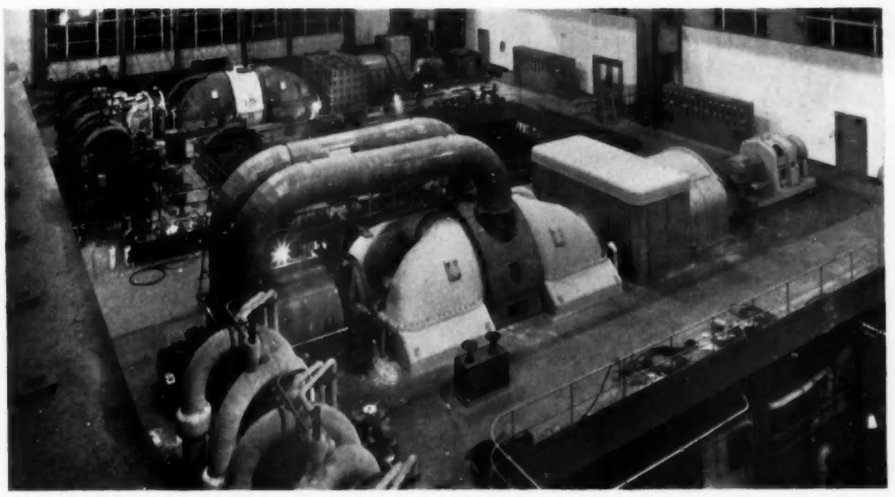


Fig. 6 General view of the extensions at Poole power station. The GEC 60 MW set on which the tests were made is in the foreground.

It will be noted that the final steady state load angles of 107·5° in Fig. 3, and 109·5° in Fig. 4 are substantially beyond the earlier theoretical limit of 90°, that is, they are well inside the dynamic stability region.

Line Switching Disturbance.—A reactor was available which had a reactance equivalent to approximately 50 miles of 132 kV overhead line. Tests were made to study the response of the AVR to sudden insertion and removal of this reactor, in direct series with the generator-transformer unit. It was found that when the alternator was running on AVR control at a high machine angle, the sudden insertion of the reactor led to a reduced angle of generation and a greater stability margin, and conversely the sudden short-circuiting of the reactor caused an increase in the angle of generation and loss of stability if the initial angle was too high. This is directly contrary to the known effect on normal hand-excitation control. Tests were made starting at 100° rotor angle, generating 60 MW with the reactor in circuit and then shorting out the reactor with and without the rotor angle limiter in service. With no limiter the set immediately fell out of step and resulted in the most severe disturbance to the system experienced during the whole series of tests. With the limiter in operation stability was easily maintained as mentioned earlier with reference to Fig. 4.

Leading MVAr Limit.—Completely stable operation was obtained when generating 60 MW, 66 MVAr lead at a terminal voltage of 11·25 kV. This gave a transmission angle between the direct axis of the machine and the 132 kV station bars of 120°. This represents a steady state limit well beyond that likely to be required in practice. The addition of ± 5 per cent current-compounding caused a variation of ± 3° in the absolute stability limit.

Synchronising on AVR Control.—Tests were made to determine how the machine would pull back into step on AVR control once pole slipping had started. In order to do this the automatic hand control follow-up equipment was disconnected, and the hand control induction regulator moved to the zero field position while the set was running on AVR control. To initiate the test, the machine was switched to hand control, resulting in zero alternator field voltage. After several seconds of pole slipping the set was restored to AVR control when invariably the machine pulled back into step even on 60 MW governor setting.

The main reason for this is that during pole slipping the terminal voltage drops so low that

Continuing

Operation and Maintenance

the AVR receives a continuous signal for peak forcing excitation. This produces a powerful re-synchronising effect, the result being clearly seen from the oscillogram of Fig. 5. The addition of the extra series reactor did not alter this performance.

Opening of the Field Switch on Load.—Tests were made by running the set on hand control at various power loads at unity power factor, opening the main field switch and reclosing it several seconds later. Results showed that up to 45 MW, re-synchronising took place without altering the excitation setting, but above this figure an increase was necessary to pull the machine back into step. This applied generally to tests with and without the field discharge resistance in circuit and also with and without the extra series reactor.

FLOOR MAINTENANCE

Complete Range of Machines Available

A complete range of floor cleaning and drying machines is announced by the British Vacuum Cleaner and Engineering Company Limited, Leatherhead, Surrey.

For cleaning floors there are two fundamental types of scrubbing machine. These are the "Chipmunk," a single-brush commercial dry-cleaning and polishing machine and light sander, and the "Musquash," which is the same machine but has the addition of a tank for liquid detergent. Both these machines are remarkably silent in operation, and have been found particularly suitable for use in hospitals. Their construction is such that they will clean under tables, beds and other articles of furniture.

A heavier type of machine, the "Hedgehog" has two intermeshing brushes driven by a 1 h.p. motor and is particularly designed for industrial use. This machine, when fitted with steel wire brushes, will scour and remove compacted oil and grease from concrete floors, but at the same time it can equally well be used, with different brushes, for such work as polishing ballroom floors. It can be fitted with a tank and sprinkler system for wet scrubbing; in this form is is known as the "Otter."

Both models can be fitted with batteries and so become completely self-contained for use in situations where trailing cables would be undesirable.

To complete the range, there are two dryers, known as the "Vampire" and the "Ferret." Both machines are rapid in action and suitable for all types of floor, the wide squeegees fitted giving effective pick-up even from irregular surfaces and undulating floors.

The "Vampire" is a heavy duty battery-driven model with a tank of the same size as the "Otter," with which machine it is generally used. The mains operated "Ferret" is complementary to the "Musquash," and is usually employed with it. A projecting suction nozzle makes it possible to use this machine to clean under tables and other furniture.

Engineering at Home

THE "LIP" BATTERY WRIST WATCH

A NUMBER of years of research in France and the USA have now led to the development of mass-producible electric wrist watches. Undoubtedly more accurate than the mechanical "wind-up" types, these watches also maintain a high standard of accuracy over much longer periods.

First on the market, some months ago, was the Hamilton[1] electric watch, which was life tested for several years before the first one was sold, and which has proven itself a most reliable and accurate timekeeper.

The French model, recently announced by Lip [2] also took some years to perfect and would appear to have some advantages over the American one. It is called an electronic watch because, during its development, it incorporated a transistor as a current switch. However, the transistor is not used in the model which is now on sale and so the watch must be considered as an electro-mechanical device similar to that of Hamilton's.

It is powered by two tiny 1·5 V parallel-connected batteries which are expected to give a highly consistent output for at least one year. The average current drain when in use is 7 micro-amperes.

Two stationary coils (shown in the drawing) form a stator system and, when energised, set up a magnetic field across the balance wheel, which constitutes a moving armature. The current through the coils is switched on and off by a contact cam which is attached to the spindle of the balance. When the balance moves in a forward direction the cam pushes a contact wire to make it connect the circuit between the batteries and the coils, and at a later stage of rotation the cam releases the wire to break the circuit. Before reaching the coils the current is made to pass through a contact shield diode to prevent sparking.

The contact cam is adjusted to the horns on the edge of the balance so that electrical contact begins just before the horns are opposite the pole pieces. This ensures that the magnetic attraction is approximately at a tangent to the balance. Besides acting as a time regulator and an armature, the balance also drives the hands of the watch.

The Lip watch is slightly arger than the Hamilton, but both are of moderate size and attractive in appearance.

Leading horologists in Britain are of the opinion that the commonplace watch of the future will be electric or electronic, and Mr. E. M. Bruton, editor of the *Horological Journal*, has said "there is every reason to believe that electric watches will be produced on a large scale within the next few years and they are potentially cheaper to manufacture than many of the present day mechanical watches."

[1] Hamilton Watch Co. Columbia Avenue, Lancaster, Pa., USA.

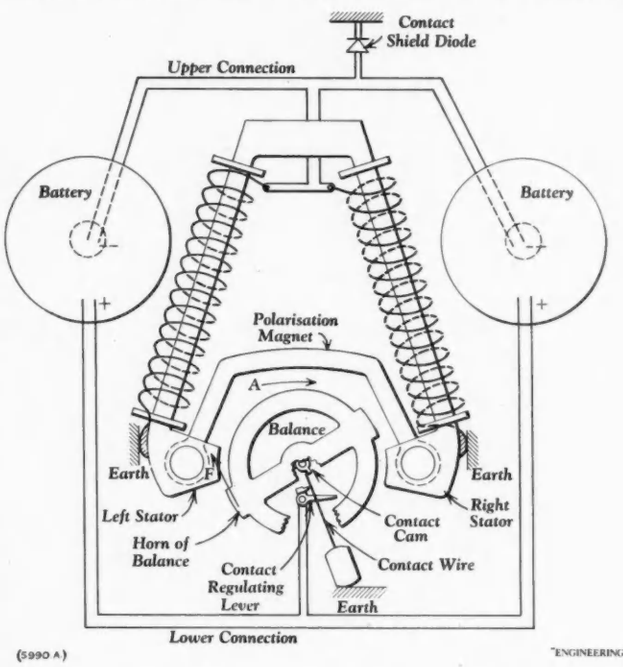
[2] Lip (S.A. de Horlogerie), rue de Chalets, Besançon, France.

Footnote

"A German paper announces that a company has been formed for the manufacture of watches to be actuated by electricity. The case contains two small cells and a small electric motor actuated by a make-and-break movement. Watches of this type have already been made, but have never hitherto been regarded as anything more than curiosities."

This news item was published by the *Horological Journal* in March, 1888.

Although conventional in appearance, the "Lip" wrist watch is battery energised.



Schematic diagram showing working principles.

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